Radiological Health Data

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VOLUME III, NUMBER 9

SEPTEMBER 1962

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SPECIAL REPORT

Additional clarifying statements have recently been issued on the interpretation of the Federal Radiation Council's Radiation Protection Guides when environmental radiation levels increase due to nuclear weapons testing fallout. This information has developed from a recent exchange of letters between the Joint Committee on Atomic Energy (JCAE) and the Federal Radiation Council (FRC).

In a letter dated June 18, 1962, to the FRC from Congressman Chet Holifield, Chairman JCAE, and Congressman Melvin Price, Chairman, Subcommittee on Research, Development, and Radiation, JCAE, information was requested in three questions relating to the interpretation of the Radiation Protection Guides.

The complete text of the JCAE questions (italicized) and answers from the FRC are contained in the following letter, dated August 17, 1962, signed by the FRC Chairman, Anthony J. Celebrezze:

FEDERAL RADIATION COUNCIL
Executive Office Building
Washington 25, D.C.

August 17, 1962

Dear Mr. Chairmen:

Your letter of June 18, 1962, points out that following the recent hearings of the Subcommittee on Research, Development and Radiation of the Joint Committee on Atomic Energy, there were unresolved questions concerning the application of radiation protection standards. Following the questions are comments of the Council.

No. 1: Are the numerical values of the Radiation Protection Guides established by the Federal Radiation Council the sole or principal criteria now used in evaluating when undesirable levels of radioactive nuclides from fallout have been reached?

No. 2: If so, is this use of the present numerical values of the Guides sufficient to indicate when and what action is appropriate to protect public health?

Comments on First Two Questions: No, the Guides are not the sole criteria used in evaluating the significance of fallout.

Since there has been widespread misunderstanding concerning these Guides, it may be useful to explain how they were developed and how they are to be used.

As you know, to be prudent we assume that there is always some slight risk to health from any level of radiation exposure, however low. Hence, setting basic radiation protection guidance involves a balancing between the requirements of total health protection (which, ideally, would tolerate no exposure) and the promotion of the use of radiation and atomic energy to achieve worthwhile benefits (which may involve exposure). With this principle in mind, the Guides were originally developed for application as guidelines for the protection of radiation workers and the general public against exposures which might result during "normal peacetime operations" in connection with the industrial use of ionizing radiation. In this connection, as noted in Chairman Ribicoff's letter of June 1 to you transmitting "Comments on the Major Unresolved Questions Concerning the Federal Radiation Council" the term "normal peacetime operations" referred specifically to the peaceful applications of nuclear technology where the primary control is placed on the design and use of the source. Since the numerical values in the Guides were designed for the regulation of a continuing industry, they were of necessity set so low that the upper limit of Range II can be considered to fall well within levels of exposure acceptable for a lifetime. Furthermore, to provide the maximum margin of safety, the upper limits of Range II were related to the lowest possible level at which it was believed that nuclear industrial technology could be developed.

It is necessary to watch the build-up of exposure levels as radiation exposures occur. A one year cumulative total has been recommended for this purpose. Obviously, this one-year span is an arbitrary measure, and no special significance should be attached to the precise cumulative exposure at the end of a 365 day period. Far more relevant are the sources of the exposure, their frequency and their likelihood of continuing.

The Guides are not intended to be a dividing line between safety and danger in actual radiation situations. Nor are they intended to set a line at which protective action should be taken or to indicate what kind of action should be taken. Some actions might in some circumstances be appropriate at levels below the Guides. Other actions might be completely inappropriate and even harmful except at levels many times above the Guide levels.

While the Guides were not specifically designed for fallout situations, they have some relevance for the assessment of fallout conditions. There is, of course, an essential difference between environmental radioactivity resulting from a long-term or permanent industrial operation and that related to intermittent production from individual weapons tests or series of weapons tests. With the former, it is predictable that introduction of radioisotopes into the environment will persist at a known rate throughout the life of the source. On the other hand, weapons tests are likely to be sporadic in nature and the radioactivity produced will rise at the time of testing and decline at varying rates for different isotopes after conclusion of a test or series of tests. While "normal peacetime operations," for which the Guides were recommended as appropriate, imply that environmental radioactivity will persist at a predetermined level throughout the human lifetime, that from fallout is likely to be extremely variable.

As applied to fallout, the Guides can be used as an indication of when there is a need for detailed evaluation of possible exposure hazards and a need to consider whether any protective action should be taken under all the relevant circumstances.

But once we are alerted to the need to consider protective action, the Guides do not tell us when to act or what to do. These judgments require careful consideration of local conditions and the impact of available health protection measures. The Council believes that individual fallout situations require individual evaluation before specific action is taken. Such an evaluation must involve a careful examination of the source and magnitude and duration of the probable exposure levels as well as a careful evaluation of the health significance of these probable exposures, and national security considerations are inevitably involved. The judgment as to when to take action and what kind of action to take to decrease exposure levels involves consideration of all of these factors. The Guides have some relevance for making this judgment, but they do not and were never intended to provide the sole basis for deciding how and when to act. It must be kept in mind that radiation exposures anywhere near the Guides involve risks so slight that countermeasures which themselves involve any slight hazard may have a net adverse rather than favorable effect on the public well-being.

In summary then, the Guides are not intended to be a dividing line between safety and danger. We have assumed that there is some slight risk to health from any level of radiation exposure, however low, even at or below the low levels set by the Guides. At the same time we do not believe there is any risk of a major health hazard until exposure levels are many times above the Guide levels. For example, this is borne out in relation to iodine-131 by the report to the Federal Radiation Council of the National Academy of Sciences, "Pathological Effects of Thyroid Irradiation," July 1962.

No. 3: If not, is the development of further or supplementary criteria needed and if so is it the responsibility of the Federal Radiation Council or the Public Health Service or others to develop and implement such criteria?

Comment: There is a continuing need for the development of guidance in this field. In accordance with Public Law 86-373, "The Council shall advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States." The appropriate Federal agencies will develop specific modes of action in accordance with such guidance.

Your letter of June 18 mentioned another important matter left open after the hearings, that of the legal responsibility and authority for invoking countermeasures.

Within the Federal Government, authority now exists under the Federal Food, Drug, and Cosmetic Act to control the shipment of adulterated food in interstate commerce. By definition, foodstuffs containing excessive radioactivity would be adulterated.

States have the authority to control intrastate distribution or sale of adulterated foods, which would include foodstuffs containing excessive amounts of radioactivity. State food and drug laws vary widely in their scope

and adequacy with respect to the problem of radioactivity in foods. The Public Health Service has the general responsibility to recommend appropriate health protection measures to States and local authorities and to the general public.

In closing, on behalf of the Council, I should like to acknowledge the Joint Committee's responsibile efforts to delineate problems relating to fallout requiring further study and clarification, and in promoting more widespread public understanding of the issues involved.

Sincerely yours,

[s] Anthony J. Celebrezze
Anthony J. Celebrezze
Chairman

The Honorable Chet Holifield
Chairman, Joint Committee on
Atomic Energy
Congress of the United States
Washington 25, D.C.

The Honorable Melvin Price
Chairman, Subcommittee on Research,
Development and Radiation

SECTION I.—AIR AND PRECIPITATION

Fission Product Beta Activity in Airborne Particulates and Precipitation

Measurements of gross beta activity of airborne particulates and precipitation are among the earliest and most sensitive indicators of increases of fission product activity in the environment. However, a direct evaluation of biological effects is not possible from these data alone.

Of the several networks or sampling programs making such measurements, the Radiation Surveillance Network, the Naval Research Laboratory, and the Canadian Radioactive Fallout Study Program are represented in the following reports.

RADIATION SURVEILLANCE NETWORK June 1962

Division of Radiological Health, Public Health Service

The Public Health Service Radiation Surveillance Network (RSN) was established in 1956 in cooperation with the Atomic Energy Commission primarily to provide a means of promptly determining increasing levels of radioactivity in air and precipitation due to fallout from nuclear weapons tests. Prior to September 1961, the Network consisted of 45 stations. Following the September 1961 resumption of nuclear weapons testing by the U.S.S.R., the Network has been expanded over a period of several months to 72 stations, whose locations are shown in figure 1.

Air

Daily 24-hour air samples are collected by a high volume air sampler with a 4-inch diameter carbon-loaded cellulose dust filter. Field measurements with a portable survey meter enable the station operator to estimate the amount of beta activity in airborne particulates at the station 5 hours after collection by comparison with a known Sr^{90}-Y^{90} source. This 5-hour delay eliminates interference from naturally-occurring radon daughters. Each operator then reports his field estimate by telephone to the Radiation Surveillance Center, Division of Radiological Health in Washington, D. C., to provide a daily national report.

The filters are then forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for a more refined measurement using a thin-window gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. The 2 counts, separated by a 7-day interval, make possible the estimation of the age of fission products and extrapolation of the activity to the time of collection. The extrapola-

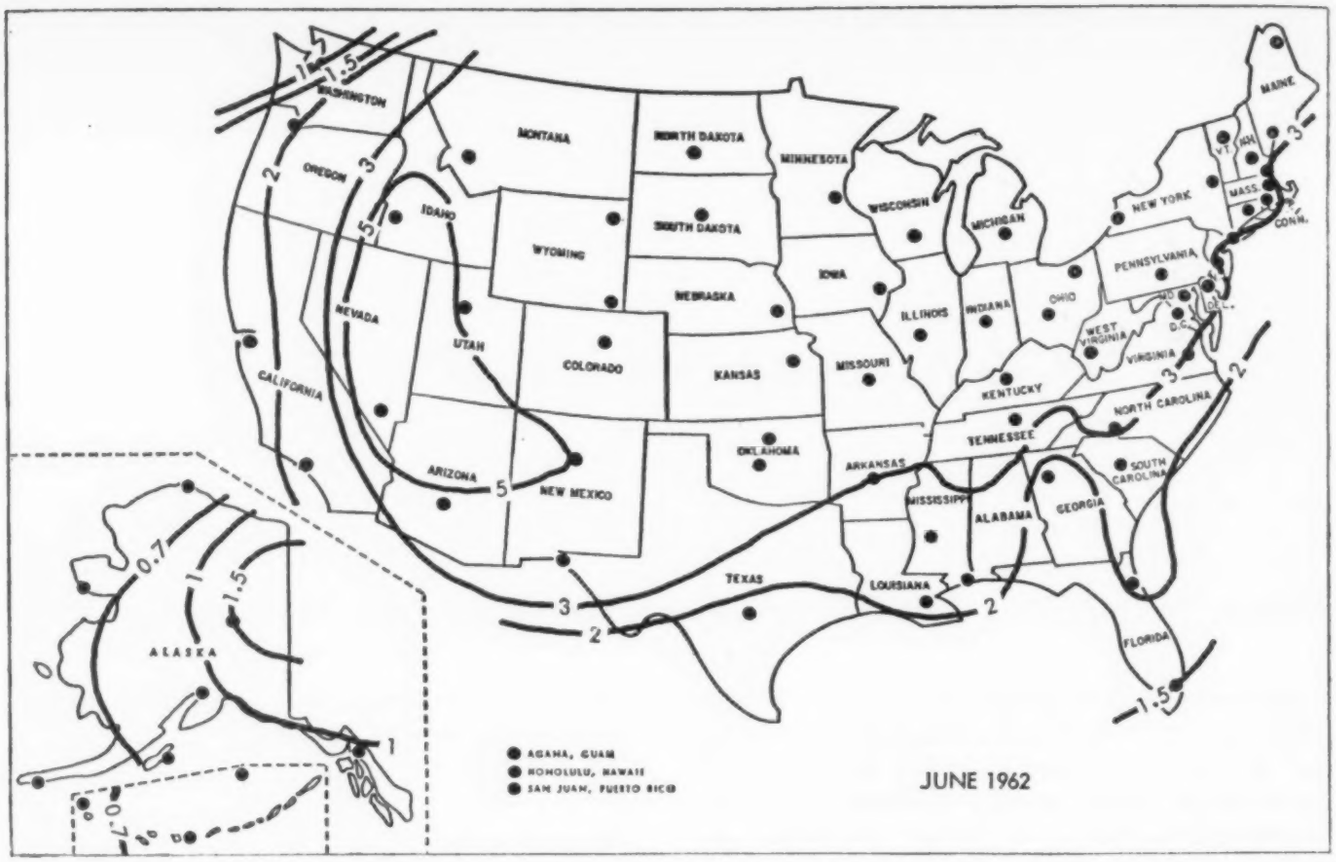


FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS AND AVERAGE FISSION PRODUCT CONCENTRATIONS IN AIR ($\mu\mu c/m^3$).

tion is performed by using the Way-Wigner formula ($AT^{1.2} = \text{constant}$).*

Although gross beta concentration is usually presented without reference to age, it is apparent that fission product activity is more adequately described when the age parameter is also given. An example of the interpretative usefulness of age of fission product data is presented in "Mid-May Iodine-131 in Fallout in the Midwest" in Section V of this issue. Because of the difficulty in determining a meaningful monthly average of age of fission products, such data have not yet been presented with the RSN data in *RHD*.

The average fission-product beta concentrations in surface air during June 1962 as determined by laboratory analysis are tabulated in table 1 and presented by means of iso-concentration contours in figure 1. Experience has shown that field estimates are generally comparable to laboratory analyses, except at low levels, where the former are usually higher because of natural thoron daughters.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis using funnels having collection areas of 0.4 square meter. A 500 ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples. If the collected sample is between 200 and 500 ml, the entire sample is evaporated; if less than 200 ml, (0.5 mm. rainfall equivalent for 0.5 square meter funnel) the volume of precipitation is reported, but no analysis is made.

The June 1962 averages of gross beta activity in precipitation, expressed in micromicrocuries per liter ($\mu\mu c$/liter) and micromicrocuries per

* In this expression, A is the activity at time T after fission product formation. Units are arbitrary.

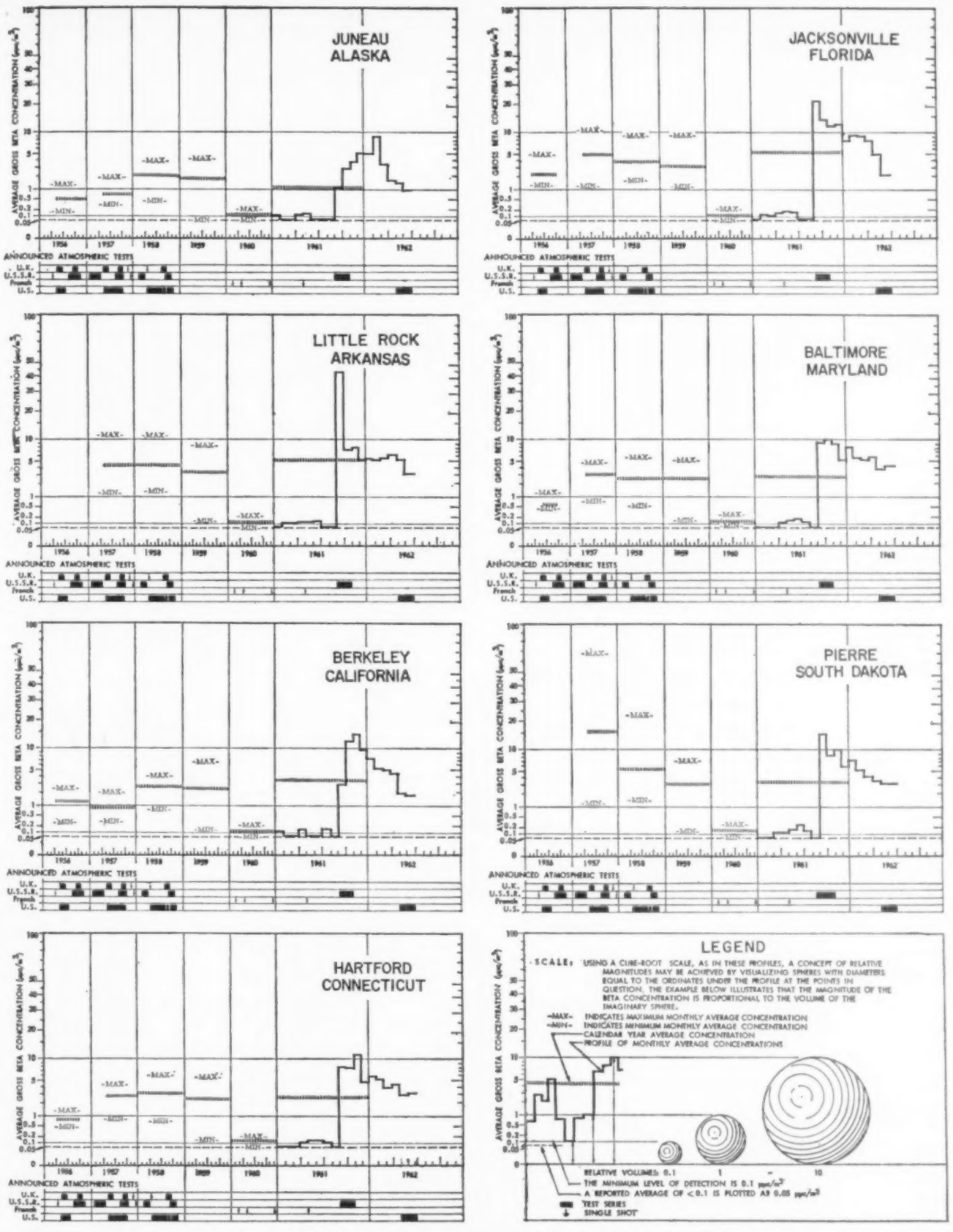


FIGURE 2.—PROFILES OF MONTHLY AND YEARLY AVERAGE FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES FOR SEVEN STATIONS, 1956—JUNE 1962

TABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, JUNE 1962

Concentrations in $\mu\mu c/m^3$

Station location		Number	Maximum	Minimum	Average*
City	State				
Adak	Alaska	30	2.7	<0.10	0.68
Anchorage	Alaska	30	2.9	<0.10	0.98
Attu	Alaska	30	3.2	<0.10	0.74
Fairbanks	Alaska	19	3.4	0.23	1.5
Juneau	Alaska	21	1.8	<0.10	0.98
Kodiak	Alaska	26	2.8	<0.10	0.80
Nome	Alaska	26	2.6	<0.10	0.67
Point Barrow	Alaska	24	1.9	<0.10	0.58
St Paul Island	Alaska	30	2.3	<0.10	0.50
Phoenix	Ariz	29	13	1.9	4.8
Little Rock	Ark	30	8.9	0.65	3.0
Berkeley	Calif	30	5.7	0.42	1.9
Los Angeles	Calif	25	5.4	1.7	2.7
Denver	Colo	28	8.7	1.3	4.4
Hartford	Conn	30	5.7	0.68	3.1
Dover	Del	20	7.9	0.21	3.9
Washington	D. C	30	7.7	0.26	3.4
Jacksonville	Fla	30	5.5	0.84	2.2
Miami	Fla	32	4.2	0.33	1.5
Atlanta	Ga	36	3.8	0.50	1.9
Agana	Guam	20	3.5	0.51	1.3
Honolulu	Hawaii	29	3.6	0.39	1.4
Boise	Idaho	30	59	2.4	6.5
Springfield	Ill	29	10	0.77	3.8
Indianapolis	Ind	30	10	0.72	3.9
Iowa City	Iowa	30	34	0.16	3.9
Topeka	Kans	31	7.8	0.36	3.3
Frankfort	Ky	28	8.5	1.2	3.3
New Orleans	La	29	8.7	0.34	2.1
Augusta	Maine	30	6.2	0.31	3.3
Presque Isle	Maine	30	6.9	<0.10	3.3
Baltimore	Md	30	10	0.37	4.5
Rockville	Md	14	8.6	0.34	5.4
Lawrence	Mass	30	5.7	0.78	2.8
Winchester	Mass	29	5.5	0.81	2.9
Lansing	Mich	30	13	0.48	4.6
Minneapolis	Minn	29	7.3	0.21	3.0
Jackson	Miss	29	7.2	0.64	2.4
Pascagoula	Miss	19	6.4	0.86	2.5
Jefferson City	Mo	30	7.3	0.79	3.2
Helena	Mont	30	9.9	0.58	4.1
Lincoln	Nebr	27	7.9	0.66	4.2
Las Vegas	Nev	22	12	2.4	6.0
Concord	N. H	16	8.6	1.3	3.9
Trenton	N. J	30	4.8	0.60	2.8
Santa Fe	N. Mex	28	12	2.5	5.0
Albany	N. Y	29	7.0	0.47	4.0
Buffalo	N. Y	30	12	0.56	4.6
New York	N. Y	17	3.7	0.94	2.5
Gastonia	N. C	30	6.1	0.75	3.3
Bismark	N. Dak	29	6.0	1.3	3.6
Columbus	Ohio	30	6.8	1.2	4.3
Painesville	Ohio	30	6.4	0.18	3.7
Oklahoma City	Okla	30	8.6	0.49	3.5
Ponca City	Okla	30	3.2	<.10	1.6
Portland	Oreg	29	3.6	0.50	2.1
Harrisburg	Pa	26	17	0.42	4.6
San Juan	P. R	—	—	—	—
Providence	R. I	30	6.3	0.81	3.3
Columbia	S. C	29	4.9	0.86	2.5
Pierre	S. Dak	30	5.2	0.92	3.3
Nashville	Tenn	27	7.7	1.2	3.8
Austin	Tex	28	5.4	0.29	1.9
El Paso	Tex	29	9.6	1.4	3.7
Salt Lake City	Utah	29	8.3	2.4	4.7
Barre	Vt	30	8.2	0.63	4.7
Richmond	Va	29	5.5	0.19	2.5
Seattle	Wash	30	1.9	0.34	1.0
Charleston	W. Va	30	7.5	1.2	3.6
Madison	Wis	30	7.5	0.29	3.8
Cheyenne	Wyo	30	7.7	1.5	4.0
Network average					3.1

* Weighted average obtained by summing the products of individual sampling times and the corresponding activities and dividing by the summation of the individual sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, JUNE 1962

Station location		Average concentration ($\mu\mu c$/liter)	Total Deposition ($\mu\mu c/m^2$)
City	State		
Adak	Alaska	*	*
Anchorage	Alaska	460	42,000
Attu	Alaska	*	*
Fairbanks	Alaska	*	*
Juneau	Alaska	500	65,000
Kodiak	Alaska	*	*
Nome	Alaska	*	*
Point Barrow	Alaska	*	*
St Paul Island	Alaska	*	*
Phoenix	Ariz	*	*
Little Rock	Ark	530	90,000
Berkeley	Calif	*	*
Los Angeles	Calif	*	*
Denver	Colo	2,700	64,000
Hartford	Conn	750	69,000
Dover	Del	*	*
Washington	D. C	830	120,000
Jacksonville	Fla	1,700	170,000
Miami	Fla	390	110,000
Atlanta	Ga	380	11,000
Agana	Guam	*	*
Honolulu	Hawaii	*	*
Boise	Idaho	3,400	4,200
Springfield	Ill	<350	<3,500
Indianapolis	Ind	4,200	35,000
Iowa City	Iowa	680	34,000
Topeka	Kans	5,800	540,000
Frankfort	Ky	770	51,000
New Orleans	La	690	170,000
Augusta	Maine	2,800	110,000
Presque Isle	Maine	710	51,000
Baltimore	Md	1,200	75,000
Rockville	Md	*	*
Lawrence	Mass	1,300	62,000
Winchester	Mass	1,100	83,000
Lansing	Mich	1,000	61,000
Minneapolis	Minn	1,100	58,000
Jackson	Miss	700	14,000
Pascagoula	Miss	480	54,000
Jefferson City	Mo	1,900	190,000
Helena	Mont	2,800	52,000
Lincoln	Nebr	1,200	78,000
Las Vegas	Nev	*	*
Concord	N H	*	*
Trenton	N J	690	2,300
Santa Fe	N Mex	1,100	12,000
Albany	N Y	640	29,000
Buffalo	N Y	1,100	79,000
New York	N Y	*	*
Gastonia	N C	420	79,000
Bismark	N Dak	1,000	77,000
Columbus	Ohio	880	45,000
Painesville	Ohio	4,400	430,000
Oklahoma City	Okla	360	41,000
Ponca City	Okla	860	110,000
Portland	Oreg	360	4,900
Harrisburg	Pa	980	42,000
San Juan	P R	*	*
Providence	R I	1,600	180,000
Columbia	S C	630	88,000
Pierre	S Dak	1,600	200,000
Nashville	Tenn	420	53,000
Austin	Tex	790	120,000
El Paso	Tex	*	*
Salt Lake City	Utah	1,500	33,000
Barre	Vt	2,300	68,000
Richmond	Va	1,500	150,000
Seattle	Wash	2,200	15,000
Charleston	W Va	850	80,000
Madison	Wis	6,000	220,000
Cheyenne	Wyo	1,200	81,000

* No evaporated sample received.

square meter ($\mu\mu c/m^2$) are presented in table 2. Placement of a "less than" sign (<) with an average concentration or total deposition value indicates that the sum of the "less than" daily deposition values is 10 percent or more of the total deposition so that the true total or average is considered significantly less than the value shown.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, updated through June 1962, are shown in figure 2.

THE 80TH MERIDIAN (WEST) SAMPLING PROGRAM
May 1962

U. S. Naval Research Laboratory

Radioactivity measurements of surface air samples collected at various sites near the 80th Meridian (West) have been made since 1956. Sampling locations are shown in figure 3. This program is operated by the U. S. Naval Research Laboratory (NRL) with the cooperation of interested agencies of the United States, Canada, Ecuador, Peru, Bolivia, and Chile, which collect the samples and forward them to NRL for analysis. Partial financial support of this program is provided by the Division of Biology and Medicine, U. S. Atomic Energy Commission.

FIGURE 3.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

The sampling procedure involves drawing air continuously for a seven-day period, at a rate of approximately 1200 cubic meters per day through a high efficiency filter, 8 inches in diameter, using a positive displacement blower. After the 7-day period, the filter is removed and forwarded to NRL for assay of gross beta activity. A minimum of 2 weeks after collection is allowed for decay of short-lived radionuclides. Data are not extrapolated to time of collection.

Analysis of the samples collected during May 1962 indicates the arrival of fresh debris from the Christmas Island tests at Lima, Chacaltaya, Antofagasta and Santiago. The distribution of activity closely parallels that observed in July 1958 during the U. S. Hardtack series in the Pacific, when activity first appeared and in highest concentrations at the high altitude sites. The levels of gross β-activity are currently such that in the Northern Hemisphere, as a result of the Fall 1961 U.S.S.R. test series, the influx of fresh debris from the Christmas Island area has not been apparent.

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NRL[1], MAY 1962

[Average concentrations in $\mu\mu c/m^3$]

Day	Punta Arenas, Chile	Puerto Montt, Chile	Santiago, Chile	Antofagasta, Chile	Chacaltaya, Bolivia	Lima, Peru	Guayaquil, Ecuador[2]	Miraflores, Panama Canal Zone	San Juan, P.R.	Mauna Loa, Hawaii[3]	Miami, Florida	Washington, D.C.	Moosonee, Ontario, Canada	Thule, Greenland
1														2.27
2														
3														
4	0.013	0.025	[4] —	0.056	0.056	0.096	—	2.41	—	4.55	8.32	6.26	3.52	1.43
5														
6														
7														
8														
9														
10														
11	0.018	0.027	0.076	1.35	3.52	3.58	—	2.54	—	5.85	9.09	7.16	7.16	3.24
12														
13														
14														
15														
16														
17														
18	—	0.024	0.537	2.18	6.76	1.62	—	1.27	—	4.48	8.78	6.48	3.72	2.59
19														
20														
21														
22														
23														
24	0.017	0.076	0.125	3.14	9.12	7.11	—	1.47	4.95	5.76	6.44	5.90	6.53	2.22
25														
26														
27														
28														
29														
30	0.018	0.021	0.159	1.68	4.22	2.90	—	1.00	0.81	3.48	2.64	4.77	3.62	5.31
31														
Weighted average	0.016	0.036	0.233	1.68	4.90	3.08	—	1.83	3.70	5.00	7.61	6.30	5.08	2.54

[1] The average concentration determined from a given sample is placed at the center of a rectangle which indicates the length and dates of the sampling period. Station averages for the month were determined by weighting the sample average according to the number of days in the sampling period of that portion of the sampling period occurring in May 1962.

[2] Motor failure.

[3] Mauna Loa data have been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters) and about equally distant north and south of the equator.

[4] Dash indicates samples were not received.

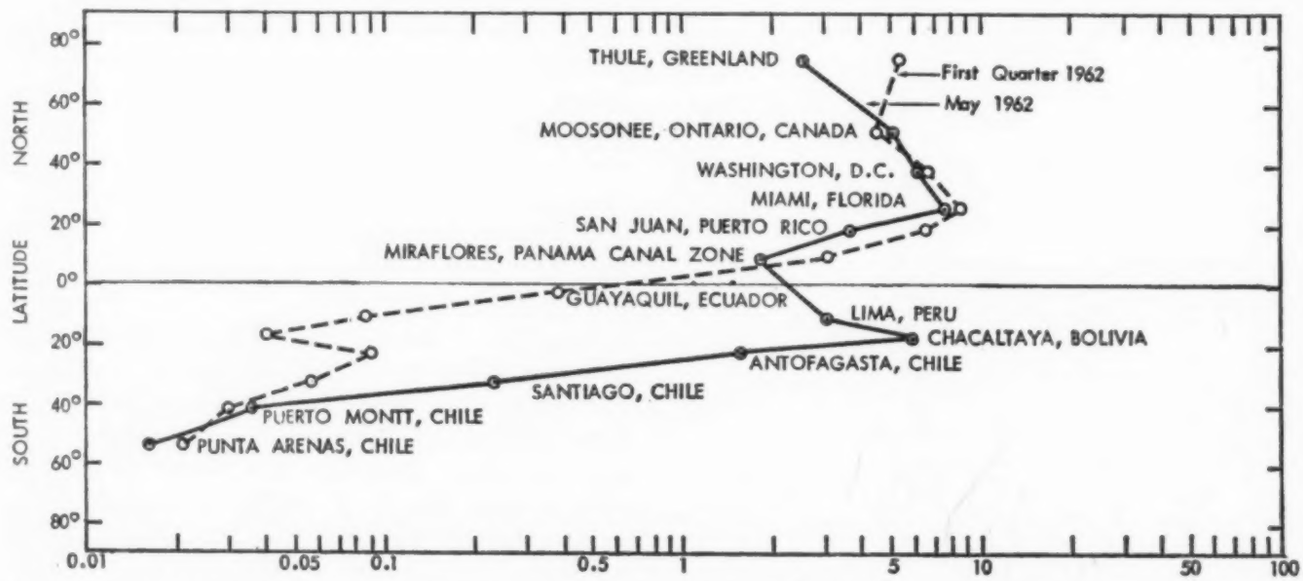


FIGURE 4.—PROFILE OF BETA ACTIVITY, AVERAGE MEASUREMENTS OF SURFACE AIR AT STATIONS NEAR THE 80TH MERIDIAN (WEST)—MAY 1962

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM
Fourth Quarter 1961

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division, Department of National Health and Welware, Dominion of Canada, conducts air and precipitation sampling programs. The 24 air and precipitation stations are located at airports, and the equipment is operated by meteorologists of the Meterological Services Branch of the Department of Transport.

FIGURE 5.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, RFSP, FOURTH QUARTER 1961

[Average concentration in $\mu\mu c/m^3$]

Station location	October	November	December	Station location	October	November	December
Calgary	20.5	27.2	10.3	Resolute	9.26	6.62	8.45
Chatham	16.0	17.8	7.70	Saskatoon	15.9	19.8	9.76
Coral Harbour	5.31	8.55	9.50	Shearwater	15.6	17.5	10.2
Edmonton	18.8	20.9	10.2	Torbay	14.2	17.2	7.15
Ft. Churchill	8.90	6.62	6.61	Toronto	23.2	20.0	10.0
Ft. William	18.7	17.3	10.8	Vancouver	12.1	21.7	8.50
Fredericton	15.2	16.0	8.25	Whitehorse	10.4	15.8	10.4
Goose Bay	7.92	10.2	6.80	Windsor	24.1	25.1	12.9
Inuvik	7.25	8.64	8.36	Winnipeg	24.8	15.1	10.7
Kapuskasing	16.2	22.0	7.29	Yellowknife	10.0	8.32	7.65
Montreal	20.4	16.9	10.4				
Moosonee	21.7	12.8	8.28	Maximum station avg	24.8	27.2	12.9
Ottawa	23.0	18.6	9.54	Minimum station avg	5.31	6.62	6.80
Regina	17.7	17.6	9.85	Overall average	15.7	16.2	9.15

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, FOURTH QUARTER

Station location	October		November		December	
	Concentration ($\mu\mu c$/liter)	Deposition ($\mu\mu c/m^2$)	Concentration ($\mu\mu c$/liter)	Deposition ($\mu\mu c/m^2$)	Concentration ($\mu\mu c$/liter)	Deposition ($\mu\mu c/m^2$)
Calgary	909.0	20,300	919.6	14,200	1843.7	22,900
Chatham	460.6	41,200	1126.3	90,100	1062.5	73,900
Coral Harbour	1199.2	25,000	2073.3	21,600	1298.0	32,000
Edmonton	2454.8	61,100	3071.9	51,500	2571.9	52,200
Fredericton	527.4	81,400	1441.0	118,600	930.2	104,700
Ft. Churchill	[a]—	—	817.7	72,600	1334.6	38,000
Ft. William	1880.2	107,500	1783.0	63,400	1586.9	44,300
Goose Bay	339.0	42,900	755.4	40,100	861.8	41,400
Inuvik	820.8	29,000	2203.9	54,300	2010.9	27,100
Kapuskasing	1807.3	120,700	725.0	49,000	310.1	18,000
Montreal	837.5	54,300	2620.5	163,800	670.4	58,100
Moosonee	904.4	103,600	1916.7	97,900	480.3	24,600
Ottawa	2489.8	96,100	946.9	55,100	1606.6	97,100
Regina	1238.8	33,700	4070.6	32,000	1194.7	21,200
Resolute	459.0	42,500	2191.8	211,600	5120.9	50,700
Saskatoon	1694.8	70,200	1561.1	29,900	1334.6	31,500
Shearwater	259.9	48,700	1606.6	180,100	652.0	80,300
Torby	986.5	92,400	1342.1	113,100	1058.0	101,900
Toronto	5592.1	59,700	1169.9	81,000	—	—
Vancouver	985.0	112,600	2606.8	373,400	1114.1	211,700
Whitehorse	2140.2	61,400	3859.3	54,900	895.2	22,000
Windsor	2109.8	63,800	1778.4	130,000	1968.4	77,500
Winnipeg	550.2	14,000	8896.6	38,400	992.6	30,500
Yellowknife	193.0	10,800	377.0	13,900	1225.1	28,300
Average	1340.8	60,600	2090.1	89,500	1396.7	56,100

[a] Dash denotes no sample.

Air

About 653 cubic meters of air is drawn through a high efficiency 4-inch diameter filter during a 24-hour period. Filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. A 2-inch diameter disk is removed from each filter and counted with a thin end-window Geiger flow counter system, calibrated with a Sr^{90}-Y^{90} standard. The delay period between collection and counting is one week to avoid interference from naturally-occurring radon and thoron daughters. Air data for fourth quarter 1961 are presented in table 4.

Precipitation

The amount of radioactive fallout being deposited on the ground is determined from measurements on material collected in special polythene lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. Fourth quarter precipitation data are given in table 5.

A more detailed discussion of the sampling procedures, methods of analysis, and interpretation of results of the Department's radioactive fallout program is contained in the "Annual Report for 1959," Report Number CNHW (RP-3).

Previous coverage in *Radiological Health Data:*

Period	*Issue*
July 1959–June 1960	*January 1961*
Third quarter 1960	*April 1961*
Fourth quarter 1960	*August 1961*
First quarter 1961	*December 1961*
Second quarter 1961	*February 1962*
Third quarter 1961	*May 1962*

Surface Air Radon, Thoron, and Fission Product Gross Beta Concentrations at Cincinnati, Ohio

May 21–June 15, 1962

Division of Radiological Health, Public Health Service

The determination of natural background radiation in our atmosphere is useful because the exposure levels from natural radiation can be used as a base for comparative evaluations of exposures from artifically produced radionuclides. Natural radioactivity in surface air is attributed to a number of unstable nuclides not produced by man. The earth's crust contains trace amounts of uranium and thorium that occur naturally and which decay through a series of their daughter products. These decay products of uranium and thorium are introduced into surface air through their rare gas daughters, radon (radon-222) and thoron (radon-220), which in turn continue to decay through the uranium and thorium series, respectively. The radon and thoron content of air depends on the escape of these rare radioactive gases from the earth. Concentrations depend on prevailing atmospheric conditions such as

TABLE 1.—SURFACE AIR RADON (Rn^{222}), THORON (Rn^{220}), AND FISSION PRODUCT GROSS BETA CONCENTRATIONS AT CINCINNATI, OHIO, MAY 21—JUNE 15, 1962

End of sampling period	Rn^{222} 8 a.m. ($\mu\mu c/m^3$)	Rn^{222} 3 p.m. ($\mu\mu c/m^3$)	Rn^{220} ($\mu\mu c/m^3$)	Beta activity ($\mu\mu c/m^3$)
May 21	230	140	4.3	7.84
22	350	120	2.8	5.17
23	390	100	2.6	7.66
24	210	80	3.1	14.47
25	640	150	7.6	9.56
28	230	100	1.7	3.18
29	270	110	1.4	9.05
31	190	90	1.7	5.89
June 1	450	100	2.7	8.73
4	520	120	6.4	4.32
5	240	80	2.6	3.70
6	770	140	6.9	2.56
7	300	100	3.9	3.49
8	410	140	4.6	7.94
11	200	80	2.6	4.66
12	190	210	1.4	6.37
13	350	90	2.2	7.41
14	670	110	4.5	6.72
15	740	130	8.2	9.36
Average	353	112	3.6	6.21
Range of counting errors (2σ) Maximum	49	25	0.9	0.23
Minimum	24	15	0.4	0.06

ambient temperature, humidity, and pressure, and on soil conditions such as moisture, porosity, and temperature.

Most of the natural radioactivity in surface air is due to radon and its daughters. Thoron and its daughters contribute much less because of thoron's short half-life and hence, a lower diffusion rate from the soil.

Radiological Health Research Activities, Research Branch, Division of Radiological Health, Public Health Service, performs a continuous daily sampling program at Cincinnati for radon, thoron, and gross beta fission product concentrations in surface air. The airborne particulates, which include the daughter products of radon and thoron, are collected continuously on a membrane filter surface at a rate of approximately 1.2 cubic meters of air per hour.

Radon–222 concentrations are determined from alpha measurements made immediately after the sampling period (24 to 72 hours) has ceased. The morning radon–222 concentrations have been corrected for any radon–220 daughter interferences. The afternoon radon–222 concentrations are derived from alpha measurements made at 3 p.m., approximately 7 hours after the new sampling period has begun. These values are from the same filters that are counted at 8 a.m. the following day. The afternoon radon–222 concentrations are uncorrected for any radon–220 daughter interferences. Radon–220 concentrations are determined from alpha measurements made on the sample used to evaluate the corrected morning radon–222 concentrations, but are counted 7 hours after the sampling period has ceased. Reported values are corrected to the time of removal of the filter. The gross beta activity of airborne particulates, when measured several days after sample collection, is due principally to artificially-produced fission products.

The data are computed by an electronic data processing system which is programmed for thirteen 4-week periods per calendar year. The data for the period May 21–June 15, 1962 appear in table 1.

REFERENCE

Setter, L. R., and G. I. Coats, "The Determination of Airborne Radioactivity," *American Industrial Hygiene Association Journal*, 22:64–9 (Feb. 1961).

SECTION II.—FOOD

Strontium–90 in Raw and Processed Foods

1960, 1961, and 1962

Pharmacology Division
Food and Drug Administration

The Food and Drug Administration (FDA) conducts a sampling program to determine the concentrations of certain radionuclides in a variety of different domestic and foreign food items, as well as in animal feeds and other items which may be of importance in the food chain. Most of the domestic products examined for strontium–90 content are raw, unwashed, and unprocessed, and are collected by FDA inspectors, either directly from individual growers or from storage sheds where products are assembled before shipment. Collection records kept by the inspectors include date of collection, date of harvest, date of planting, name of grower or growers, location of farm by county or State, and name and location of marketing cooperative or dealer. When manufactured items are collected, information on the source of the raw materials is recorded.

Although samples are not collected according to a regular schedule or fixed geographical grid, the major growing areas for all of the products are sampled at intervals which usually coincide with harvest dates for the specific crop. Decisions as to what products to sample, sampling intervals, and assigned priorities are reviewed annually and incorporated into a surveillance program which is continually adjusted to cover special fallout situations associated with worldwide nuclear weapons testing. The current program comprises collection of 3500 single samples representing 50 categories of domestic, foreign, and animal foods and analysis for strontium–90. Limited analyses for cesium–137 and iodine–131 are done by gamma spectrometry.

Currently, the method used by the FDA laboratories for the analysis of strontium–90 is a modification of that outlined in the *HASL Manual of Standard Procedures* (*1*), and involves ashing the food at 550 to 600° C, dissolving the ash in hydrochloric acid, precipitating strontium and calcium as oxalates, and separating the strontium from the calcium in concentrated nitric acid. After the radium and lanthanides are scavenged with barium chromate, strontium is determined either by isolation and measurement of the daughter product yttrium–90 after secular equilibrium has been established or by direct measurement as strontium–90 with correction for ingrowth of yttrium–90. The latter method is the procedure of choice because it obviates the 3-week delay period necessary for ingrowth of yttrium–90. It also determines strontium–89, the presence of which renders this latter method currently not applicable.

Table 1 presents some limited data on the effect of processing on the strontium–90 con-

[Continued on page 332]

TABLE 1.—EFFECT OF PROCESSING ON THE STRONTIUM-90 CONTENT OF SOME FOOD ITEMS

Food item	Number of samples	μμc Sr^{90}/kg				Percent reduction
		Raw		Canned or frozen		
		Average	Range	Average	Range	
Beans snap	33	16.2	2.0–98	6.9	0.4–30	58
Broccoli	1	9.8		5.0		49
Brussel sprouts	2	7.2	6.3– 8.1	3.0	2.4– 3.6	28
Carrots	21	6.8	0.8–21	5.9	0.7–23	13
Peaches	11	1.4	0.4– 4.0	0.8	0.1– 2.2	43
Spinach	30	14.8	2.7–55	12.4	1.8–36	16
Tomatoes	44	1.5	0.1– 5.3	1.0	0.1– 2.2	33

TABLE 2—STRONTIUM-90 CONTENT OF VARIOUS FOODS

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Vegetables					
Artichokes	1	Calif.	Monterey	Dec. 12, 1961	[a]4.0
Asparagus	1	Calif.	Kern	May 20, 1961	0.5
	9	N. C.	Robeson	Apr. 19, 1961	[a]5.4
Beans					
Blackeye pea	1	Calif.	Grange	Sept. 30, 1961	[a]1.4
			Fresno	Oct. 1961	[a]4.5
			San Joaquin	Oct. 1961	[a]2.6
			Stanislaus	Oct. 1961	[a]4.1
			Riverside	Nov. 1, 1961	[a]0.3
Lima	1	Calif.	Santa Barbara	Sept. 15, 1961	0.1
			Ventura	Sept. 15, 1961	2.9
			Sutter	Oct. 1961	[a]1.0
			Santa Clara	Oct. 4, 1961	[a]0.4
				Oct. 5, 1961	[a]3.7
				Oct. 6, 1961	[a]2.3
			Santa Clara	Oct. 4, 1961	[a]0.4
				Oct. 5, 1961	[a]3.7
				Oct. 6, 1961	[a]2.3
unwashed			Santa Clara	Oct. 4, 1961	[a]0.4
				Oct. 5, 1961	[a]6.8
				Oct. 6, 1961	[a]4.7
	9	N. C.	Henderson	Sept. 13, 1961	2.7
Navy	5	Mich.	Lapeer	Sept. 1, 1961	2.8
			Shiawassee	Oct. 30, 1961	[a]4.9
Pinto	1	Idaho	Twin Falls	Sept. 6, 1961	11
		Wash.	Adams	Sept. 10, 1961	6.1
	2	Colo.	Montezuma	Sept. 1, 1961	6.5
Red	1	Wash.	Benton	Aug. 1961	4.8
			Grant	Oct. 25, 1961	[a]6.1
Snap		Calif.	Monterey	Sept. 6, 1961	1.1
				Sept. 6, 1961	2.2
			Santa Cruz	Oct. 4, 1961	[a]1.0
				Oct. 4, 1961	[a]4.0
				Oct. 4, 1961	[a]7.7
	5	Mich.	Tuscola	Aug. 16, 1961	8.0
			Van Buren	Aug. 18, 1961	35
Beets					
washed, unpeeled	1	Calif.	San Diego	Feb. 15, 1962	[a]21.
		Ore.	Multnomah	Nov. 25, 1961	[a]38.
		Wash.	Spokane	Oct. 15, 1961	[a]6.7
	3	Tex.	Hidalgo	Feb. 13, 1962	[a]0.7
	4	Minn.	Anoka	Oct. 1, 1961	[a]12
	5	Wis.	Ozaukee	Nov. 10, 1961	[a]10
			Waukesha	Nov. 10, 1961	[a]12
	11	N. Y.	Ontario	Nov. 14, 1961	[a]5.8
			Wayne	Nov. 7, 1961	[a]5.8
				Nov. 15, 1961	[a]12
			Yates	Nov. 14, 1961	[a]12

[a]Harvested after September 15, 1961. [b]Refers to date of import. [c]Collection date. [d]Manufacture date.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Beets (continued) unwashed	3	Tex.	Hidalgo	Nov. 6, 1962	[a]0.9
peeled	1	Calif.	Los Angeles	Mar. 21, 1962	[a]8.7
			Riverside	Mar. 8, 1962	[a]1.0
Broccoli	1	Calif.	Santa Barbara	Feb. 14, 1962	[a]35
	11	N. Y.	Monroe, Orleans	Nov. 14, 1961	[a]9.8
Brussel Sprouts		N. Y.	Monroe, Orleans	Nov. 12, 1961	[a]6.3
			Niagara, Orleans	Nov. 6, 1961	[a]8.1
Cabbage	1	Calif.	Imperial	Feb. 21, 1962	[a]1.4
			Riverside	Mar. 6, 1962	[a]4.4
		Ore.	Multnomah	Dec. 7, 1961	[a]10
	3	Tex.	Bexar	Jan. 6, 1962	[a]3.4
			Dimmit	Jan. 16, 1962	[a]2.9
			Hidalgo	Jan. 5, 1962	[a]2.1
				Jan. 17, 1962	[a]2.8
				Feb. 13, 1962	[a]4.6
				Mar. 3, 1962	[a]5.8
			Zavala	Nov. 8, 1960	2.6
				Jan. 17, 1962	[a]2.6
	5	Mich.	Ionia	Oct. 5, 1961	[a]3.7
			Muskegon	Nov. 29, 1961	[a]4.8
			Wayne	Sept. 13, 1961	5.8
	7	Ind.	St. Joseph	Nov. 5, 1961	[a]3.1
	8	Ala.	Mobile	Dec. 8, 1961	[a]32
		La.	Jefferson	Dec. 5, 1961	[a]17
			LaFourche	Nov. 19, 1961	[a]9.9
			Plaquemines	Dec. 4, 1961	[a]9.4
				Dec. 6, 1961	[a]8.2
			St. Charles	Nov. 25, 1961	[a]8.1
			St. James	Nov. 25, 1961	[a]8.1
	9	Fla.	Palm Beach	Jan. 16, 1962	[a]15
			St. Johns	Jan. 22, 1962	[a]22
		S. C.	Beaufort	Feb. 8, 1962	[a]51
			Charleston	Dec. 1961	[a]45
	10	Va.	Carroll	Nov. 9, 1961	[a]17
	11	N. Y.	Cortland	Nov. 5, 1961	[a]12
			Onondaga	Nov. 8, 1961	[a]14
			Ontario, Yates	Nov. 10, 1961	[a]7.3
				Nov. 10, 1961	[a]12
			Orleans	Nov. 8, 1961	[a]4.3
				Nov. 8, 1961	[a]8.2
				Nov. 8, 1961	[a]9.9
				Nov. 9, 1961	[a]5.1
		Pa.	Cambria	Oct. 5, 1961	[a]12
Carrots	1	Calif.	Riverside	Jan. 31, 1961	[a]1.0
				Feb. 27, 1962	[a]1.5
			Ventura	Feb. 14, 1962	[a]3.2
	3	Ariz.	Yuma	Jan. 15, 1962	[a]1.7
		Tex.	Bexar	Jan. 17, 1962	[a]2.0
			Hidalgo	Jan. 5, 1962	[a]0.9
				Feb. 13, 1962	[a]3.0
				Feb. 27, 1962	[a]2.6
				Mar. 3, 1962	[a]2.2
				Mar. 3, 1962	[a]4.6
			Zavala	Jan. 1962	[a]2.4
				Jan. 16, 1962	[a]2.9
	5	Mich.	Antrim	Nov. 1, 1961	[a]7.7
			Cass, Calhoun	Nov. 1, 1961	[a]2.8
			Newaygo	Oct. 10, 1961	[a]3.2
				Nov. 26, 1961	[a]2.9
		Wis.	Waukesha	Jan. 10, 1962	[a]5.4
	11	N. Y.	Ontario	Nov. 1, 1961	[a]5.2
				Nov. 7, 1961	[a]4.4
				Nov. 11, 1961	[a]9.6
				Nov. 14, 1961	[a]5.6
				Nov. 14, 1961	[a]8.3
			Wayne	Nov. 3, 1961	[a]2.8
				Nov. 13, 1961	[a]2.3
			Yates	Nov. 3, 1961	[a]2.3

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Carrots (continued)	12	Mass.	Middlesex	Sept. 7, 1960	16
Cauliflower	1	Ore.	Multnomah	Dec. 5, 1961	[a]10
	11	N. Y.	Monroe	Nov. 14, 1961	[a]1.3
			Niagara, Orleans	Nov. 16, 1961	[a]4.5
			Orleans	Nov. 14, 1961	[a]4.3
			Suffolk	Dec. 5, 1961	[a]6.4
Celery	1	Calif.	Monterey	Oct. 31, 1961	[a]1.7
				Dec. 4, 1961	[a]1.9
			Orange	Mar. 5, 1962	[a]7.1
			San Diego	Feb. 14, 1962	[a]17
	3	Tex.	Starr	Jan. 8, 1962	[a]6.1
	5	Mich.	Allegan	July 1960	14
			Kent	Sept. 5, 1960	4.4
			Lapeer	May 15, 1961	8.0
	9	Fla.	Palm Beach	Jan. 12, 1961	2.7
				Dec. 5, 1961	[a]0.9
				Jan. 16, 1962	[a]4.2
				Jan. 16, 1962	[a]5.4
			Sarasota	Jan. 16, 1962	[a]37
			Seminole	Feb. 15, 1962	[a]22
	11	N. Y.	Orange	Sept. 15, 1960	4.5
			Wayne	Sept. 3, 1960	3.4
				Sept. 30, 1960	4.0
Collards	8	Ala.	Chilton	Nov. 28, 1961	[a]42
		La.	St. Bernard	Dec. 9, 1961	[a]33
	9	N. C.	Beaufort	Dec. 12, 1961	[a]63
	10	Va.	Norfolk	Apr. 19, 1962	[a]209
Egg plant	9	Fla.	Broward	Jan. 10, 1962	[a]6.5
			Hardee	Jan. 12, 1962	[a]4.3
Kale	10	Va.	Norfolk	Apr. 19, 1962	[a]138
Lettuce	1	Calif.	Contra Costa	Oct. 18, 1961	[a]1.2
				Oct. 18, 1961	[a]1.3
			Monterey	Nov. 2, 1960	15
				Dec. 7, 1961	[a]21
				Dec. 7, 1961	[a]26
			Riverside	Dec. 11, 1961	[a]4.2
				Mar. 5, 1962	[a]6.8
	2	Colo.	Costilla	Aug. 31, 1960	3.4
	3	N. Mex.	Dona Ana	Oct. 14, 1960	2.3
			Valencia	Sept. 14, 1960	1.1
		Tex.	Hidalgo	Feb. 8, 1961	3.2
	5	Wis.	Waushara	Oct. 6, 1960	4.7
	9	Fla.	Hillsborough	Dec. 6, 1961	[a]1.5
			Palm Beach	Jan. 17, 1962	[a]0.7
			Sarasota	Feb. 5, 1962	[a]64
				Feb. 10, 1962	[a]19
				Feb. 10, 1962	[a]22
				Feb. 10, 1962	[a]30
				Feb. 10, 1962	[a]46
				Feb. 13, 1962	[a]22
				Feb. 13, 1962	[a]178
			Sumter	Dec. 6, 1961	[a]1.4
Mustard greens	1	Calif.	Santa Clara	Feb. 13, 1961	[a]91
Okra	8	La.	St. Charles	Sept. 25, 1961	[a]16
Onions, washed, unpeeled	1	Calif.	Monterey	Sept. 25, 1961	[a]2.1
			Siskiyou	Sept. 21, 1961	[a]1.3
	5	Mich.	Mason	Oct. 12, 1961	[a]0.9
			Newaygo	Sep. 8, 1961	1.2
				Oct. 10, 1961	[a]1.0
				Oct. 11, 1961	[a]1.4
				Oct. 12, 1961	[a]0.7
			Ottawa	Aug. 1961	0.9
	7	Ind.	St. Joseph	Oct. 1961	[a]0.8
		Ohio	Huron	Sept. 1, 1961	1.9
	11	N. Y.	Madison	Nov. 16, 1961	[a]1.1
				Nov. 30, 1961	[a]1.0
			Wayne	Sept. 15, 1961	0.5

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Onions (continued)					
peeled	2	S. C.	Beaufort	Jan. 19, 1962	[a]22
green, tops & roots removed	1	Calif.	Fresno	Nov. 29, 1961	[a]1.2
	3	Ariz.	Maricopa	Mar. 3, 1962	[a]7.0
	8	Ala.	Mobile	Dec. 8, 1961	[a]60
Parsley	1	Calif.	Fresno	Jan. 16, 1962	[a]95
				Jan. 23, 1962	[a]126
			Monterey	Dec. 7, 1961	[a]73
				Feb. 8, 1962	[a]64
				Feb. 8, 1962	[a]66
			San Benito	Jan. 25, 1962	[a]107
				Jan. 30, 1962	[a]126
			Santa Cruz	Jan. 31, 1962	[a]141
Peas	1	Calif.	Kern, Tulare	Dec. 5, 1961	[a]1.0
			Stanislaus	May 10, 1961	1.0
			Ventura	May 3, 1961	0.7
		Idaho	Latah	Aug. 12, 1960	4.7
			Nez Perce	Aug. 10, 1960	4.3
		Ore.	Umatilla	July 5, 1960	6.2
				July 15, 1960	5.3
		Wash.	Spokane	Aug. 1, 1960	2.4
			Whitman	Aug. 1, 1960	4.3
	9	Fla.	Hillsborough	Dec. 5, 1961	[a]14
				Dec. 5, 1961	[a]20
Peppers					
sweet	8	La.	Plaquemines	Nov. 26, 1961	[a]1.7
chili		Mexico		Mar. 8, 1962[b]	[a]1.9
dried		Japan		Dec. 7, 1961[b]	[a]14
				Dec. 11, 1961[b]	[a]2.6
				Dec. 28, 1961[b]	[a]88
				Jan. 9, 1962[b]	[a]27
				Feb. 7, 1962[b]	[a]21
Potatoes					
White, whole	1	Ore.	Malheur	Sept. 15, 1961	1.1
		Wash.	Adams	Aug. 1, 1961	0.7
			Kittitas	Sept. 1961	0.4
	4	Minn.	Marshall	Sept. 1961	1.6
			Pennington	Oct. 1, 1961	[a]1.4
			Red Lake	Oct. 1, 1961	[a]2.4
			Roseau	Oct. 1, 1961	[a]1.1
		N. D.	Grand Forks	Sept. 1961	1.4
				Sept. 20, 1961	[a]0.8
			Traill	Oct. 1, 1961	[a]0.8
	5	Mich.	Bay	Sept. 1, 1960	8.8
			Lapeer	Oct. 1961	[a]0.4
				Oct. 1961	[a]0.4
			Macomb	Nov. 1, 1961	[a]1.0
			Marion	Oct. 15, 1961	[a]0.0
			Missaukee	Sept. 25, 1961	[a]0.9
			St. Clair	Oct. 5, 1961	[a]1.3
			Shiawassee	Dec. 18, 1961	[a]0.7
	5	Wis.	Langlade	Sept. 1961	2.0
				Oct. 20, 1961	[a]1.2
			Racine	Oct. 1, 1961	[a]3.4
			Waukesha	Oct. 1961	[a]2.0
	6	Ill.	Carroll	Sept. 25, 1961	[a]2.6
			Whiteside	Oct. 1, 1961	[a]2.0
	7	Ohio	Clinton	Oct. 16, 1961	[a]3.5
			Richland, Wayne	Oct. 5, 1961	[a]1.2
	11	Pa.	Bucks	Oct. 10, 1961	[a]2.3
			Cambria	Oct. 10, 1961	[a]1.7
			Indiana	Oct. 21, 1961	[a]2.0
			Jefferson	Oct. 10, 1961	[a]1.4
			Somerset	Oct. 8, 1961	[a]1.3
peeled	1	Calif.	Riverside	Feb. 17, 1962	[a]0.6
	4	Minn.	Polk	Sept. 1961	0.7
	5	Mich.	Bay	Sept. 1961	0.7
			Newaygo	Oct. 27, 1961	[a]0.4
		Wis.	Waupaca	Oct. 1, 1961	[a]2.0

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Potatoes (continued)	7	Ind.	St. Joseph	Oct. 1, 1961	[a]0.0
	11	Pa.	Erie	Sept. 20, 1961	[a]0.4
peelings	1	Calif.	Riverside	Feb. 17, 1961	[a]4.7
	4	Minn.	Polk	Sept. 1961	2.8
	5	Mich.	Bay	Sept. 1961	3.0
			Newaygo	Oct. 27, 1961	[a]2.6
		Wis.	Waupaca	Oct. 1, 1961	[a]5.9
	7	Ind.	St. Joseph	Oct. 1, 1961	[a]0.7
	11	Pa.	Erie	Sept. 20, 1961	[a]6.0
sweet	3	Tex.	Van Zandt	Oct. 15, 1961	[a]16
	9	Georgia	Thomas	Nov. 1961	[a]44
	10	Maryland	Wicomico	Oct. 1961	[a]23
		New Jersey	Atlantic	Oct. 9, 1961	[a]20
				Oct. 14, 1961	[a]19
				Oct. 15, 1961	[a]21
Pumpkin	1	Ore.	Yamhill	Oct. 10, 1961	[a]11
		Wash.	King	Oct. 15, 1961	[a]3.4
	2	Colo.	Boulder	Oct. 15, 1962	[a]3.2
				Oct. 15, 1962	[a]3.6
	6	Ill.	LaSalle	Oct. 1961	[a]5.4
			Lee	Oct. 1961	[a]3.5
			Will	Oct. 1961	[a]4.6
	9	N. C.	Henderson	Nov. 1961	[a]0.5
				Nov. 1961	[a]3.9
	10	Md.	Howard, Montgomery	Nov. 8, 1961	[a]7.7
		Va.	Roanoke	Oct. 8, 1961	[a]4.8
Radishes	1	Calif.	Los Angeles	Mar. 8, 1962	[a]2.6
				Mar. 20, 1962	[a]10
			San Diego	Feb. 15, 1962	[a]3.8
	9	Fla.	Palm Beach	Dec. 11, 1961	[a]6.1
Soybeans	3	Tex.	Lubbock	Oct. 1961	[a]20
			Swisher	Oct. 1961	[a]17
	4	Minn.	Kandiyohi	Sept. 1961	18
	5	Wis.	Pierce	Sept. 1961	42
			St. Croix	Sept. 1961	34
	6	Ill.	Lee	Oct. 1961	[a]26
			Whiteside	Oct. 1961	[a]24
	7	Ind.	Adams	Oct. 15, 1961	[a]11
			DeKalb	Oct. 15, 1961	[a]20
	9	Ga.	Peach	Nov. 1961	[a]116
		S. C.	Allendale	Oct. 25, 1961	[a]151
			Orangeburg	Nov. 15, 1961	[a]108
	11	Pa.	Bucks	Sept. 1961	64
Spinach	1	Calif.	Los Angeles	Feb. 27, 1962	[a]167
			Orange	Mar. 19, 1962	[a]55
			Ventura	Feb. 14, 1962	[a]74
		Wash.	King	Sept. 11, 1961	[a]6.8
			Pierce	Sept. 27, 1961	[a]14
	3	Tex.	Hidalgo	Jan. 31, 1962	[a]33
	10	Md.	Kent	Apr. 10, 1962	[a]104
	11	N. Y.	Genesee	Oct. 2, 1961	[a]3.1
			Yates	Sept. 29, 1961	[a]2.9
Squash	5	Mich.	Lapeer	Oct. 15, 1961	[a]2.2
				Oct. 15, 1961	[a]2.2
Turnips whole	1	Calif.	San Diego	Feb. 15, 1962	[a]2.8
	8	La.	St. John the Baptist	Nov. 19, 1961	[a]3.6
				Nov. 26, 1961	[a]12
				Nov. 26, 1961	[a]9.4

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Turnips (continued)	11	N. Y.	Erie	Nov. 1, 1961	[a]6.5
		Pa.	Bucks	Nov. 30, 1961	[a]32
peeled	1	Calif.	Orange	Feb. 28, 1962	[a]5.9
			Riverside	Mar. 9, 1962	[a]1.6
Fruit					
Apples	1	Calif.	Santa Cruz	Oct. 1961	[a]0.2
				Oct. 30, 1961	[a]0.3
	5	Mich.	Berrien	Oct. 10, 1961	[a]2.0
	7	Ohio	Erie, Lorain	Sept. 20, 1961	[a]1.5
	11	N. Y.	Essex	Sept. 18, 1961	[a]1.5
			Washington	Sept. 18, 1961	[a]0.5
			Wayne	Oct. 9, 1961	[a]1.3
Avocado	1	Calif.	Orange	Feb. 1, 1962	[a]0.4
			San Diego	Feb. 2, 1962	[a]0.1
			Ventura	Feb. 15, 1962	[a]0.8
peeled & pitted			San Diego	Jan. 15, 1962	[a]1.0
				Feb. 13, 1962	[a]2.1
			Santa Barbara	Feb. 13, 1962	[a]4.7
Bananas		Panama		Jan. 17, 1962	[a]0.1
Cranberries	10	N. J.	Burlington	Nov. 5, 1961	[a]110
				Nov. 12, 1961	[a]32
				Nov. 20, 1961	[a]78
			Ocean	Nov. 7, 1961	[a]56
Cucumber	9	Fla.	Lee	Mar. 10, 1962	[a]8.3
Figs		Greece		Oct. 16, 1961[b]	[a]7.2
				Oct. 16, 1961[b]	[a]9.0
				Oct. 27, 1961[b]	[a]3.5
		Italy		Oct. 6, 1961[b]	[a]6.7
		Turkey		Oct. 16, 1961[b]	[a]9.0
				Oct. 30, 1961[b]	[a]8.5
				Nov. 29, 1961[b]	[a]9.5
Grapes	11	N. Y.	Chautauqua	Nov. 3, 1961	[a]7.9
		Pa.	Erie	June 28, 1961	4.6
				Nov. 9, 1961	[a]4.6
				Nov. 9, 1961	[a]5.3
				Nov. 9, 1961	[a]7.6
Grapefruit, whole	1	Calif.	Riverside	Mar. 8, 1962	[a]0.4
	3	Ariz.	Yuma	Mar. 15, 1962	[a]2.0
	9	Fla.	Orange	Jan. 24, 1962	[a]11
			Polk	Jan. 13, 1962	[a]16
peeled	3	Ariz.	Maricopa	Jan. 24, 1962	[a]1.4
		Tex.	Cameron	Dec. 7, 1961	[a]0.8
			Hidalgo	Dec. 7, 1961	[a]1.7
				Jan. 3, 1962	[a]1.5
			Willacy	Jan. 9, 1962	[a]1.5
Lemons, peeled	1	Calif.	San Diego	Mar. 2, 1962	[a]1.8
			Ventura	Dec. 12, 1961	[a]1.1
	3	Ariz.	Maricopa	Jan. 24, 1962	[a]1.1
Limes	9	Fla.	Dade	Jan. 4, 1962	[a]13
			Pasco	Jan. 17, 1962	[a]9.0
Olives	1	Calif.	Butte	1961	12
			Los Angeles	Jan. 31, 1962	[a]3.1
Oranges, whole	9	Fla.	Indian River	Jan. 9, 1962	[a]27
			Lake	Jan. 18, 1962	[a]12
				Jan. 18, 1962	[a]15
			St. Lucie	Jan. 9, 1962	[a]24
peeled	1	Calif.	Riverside	Jan. 31, 1962	[a]1.5
				Feb. 28, 1962	[a]0.8
			San Bernadino	Feb. 1, 1962	[a]1.0
				Mar. 16, 1962	[a]1.1
			San Diego	Feb. 15, 1962	[a]2.2
Peaches	1	Calif.	Stanislaus	Sept. 4, 1961	0.4
	5	Mich.	Berrien	Sept. 28, 1961	[a]1.1
			Mason	Sept. 26, 1961	[a]4.0
			Oceana	Sept. 20, 1961	[a]1.6

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Pears	1	Ore.	Hood River	Oct. 1961	[a]1.0
		Wash.	Douglas	Aug. 1961	0.4
	11	Pa.	Bucks	Oct. 15, 1961	[a]3.2
Pineapple, canned		Phillipine Islands		Dec. 28, 1961[b]	[a]2.3
		Hawaii		Feb. 7, 1961[b]	2.1
Tomatoes					
ripe	1	Calif.	Butte	Nov. 1, 1961	[a]0.5
			Monterey	Oct. 30, 1961	[a]0.3
			San Diego	Feb. 15, 1962	[a]0.2
			Santa Clara	Sept. 18, 1961	[a]0.2
			Yolo	Sept. 11, 1961	0.5
	5	Mich.	Lenawee	Aug. 31, 1961	0.7
	7	Ind.	Blackford	Sept. 27, 1961	[a]0.3
			Wells	Sept. 28, 1961	[a]0.5
	9	Fla.	Dade	Mar. 2, 1961	1.8
	10	Va.	Northumberland	Aug. 25, 1960	2.6
green	9	Fla.	Hillsborough	Jan. 16, 1962	[a]5.8
			Manatee	Jan. 16, 1962	[a]2.8
Cereals					
Barley	1	Idaho	Nez Perce	July 20, 1961	11
		Ore.	Marion	Sept. 1961	4.4
		Wash.	Whitman	July 1961	4.0
	2	Colo.	Morgan	July 1, 1961	15
		Utah	Sevier	Sept. 10, 1961	11
				Sept. 10, 1961	11
	3	N. Mex.	Dona Ana	June 5, 1961	12
		Okla.	McClain	July 1961	13
		Tex.	Randall	Jan. 17, 1962	[a]9.6
	4	Minn.	Dakota	Aug. 15, 1961	15
				Aug. 15, 1961	23
			Hennepin	Aug. 15, 1961	26
	5	Mich.	Bay, Saginaw	July 20, 1961	8.0
			Tuscola	July 20, 1961	9.0
		Wis.	Calumet	Aug. 1, 1961	14
			Kewaunee	Aug. 15, 1961	25
	10	Del.	Sussex	June 1961	37
		Md.	Carroll	June 1961	23
		N. J.	Hunterdon	Sept. 1961	27
		Va.	Roanoke	June 15, 1961	12
	11	N. Y.	Genesee	Aug. 1, 1961	9.2
Corn, meal	4	Kans.	Shawnee	Sept. 20, 1960	0.1
shelled	1	Idaho	Canyon	Oct. 15, 1961	[a]0.0
		Ore.	Malheur	Nov. 15, 1961	[a]0.3
			Marion	Oct. 1, 1961	[a]1.0
		Wash.	Yakima	Oct. 1, 1961	[a]0.4
	3	Okla.	Garfield	Oct. 1961	[a]1.3
		Tex.	Lamb	Jan. 1, 1962	[a]3.3
	4	Kans.	Shawnee	Sept. 20, 1960	0.1
	5	Mich.	Calhoun	Nov. 1, 1961	[a]0.6
		Wis.	Pierce	Nov. 1, 1961	[a]1.1
				Nov. 1, 1961	[a]3.7
	7	Ind.	Marshall	Oct. 1961	[a]0.7
			St. Joseph	Nov. 1, 1961	[a]1.2
shelled	9	Ga.	Floyd	Oct. 15, 1961	[a]1.6
	10	Va.	Louisa	Oct. 1960	2.7

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Corn (continued)	11	N. Y.	Genesee	Oct. 1, 1961	[a]0.6
			Seneca	Nov. 1961	[a]0.7
		Pa.	York	Oct. 30, 1961	[a]1.1
Oats	1	Idaho	Bonneville	Aug. 1960	17
				Aug. 1961	[b]5.3
				Aug. 1961	12
				Sept. 5, 1961	14
			Latah	Sept. 1, 1961	6.0
		Ore.	Marion	Sept. 1961	20
		Wash.	Whitman	Aug. 1961	4.8
	2	Colo.	Rio Grande	Aug. 5, 1961	16
	3	Tex.	Randall	Aug. 1961	39
	4	Minn.	Wright	Aug. 1961	25
		S. Dak.	Davison	Aug. 1961	13
	5	Mich.	Calhoun	July 15, 1961	23
			Kalamazoo	July 25, 1961	16
	6	Ill.	Stephenson	Aug. 1961	26
	7	Ohio	Fulton	Aug. 1, 1961	14
	11	N. Y.	Genesee	Aug. 1, 1961	21
			Seneca, Ontario	Aug. 15, 1961	11
			Wyoming	Aug. 20, 1961	30
		Pa.	Bucks	Aug. 1961	20
Rye	1	Ore.	Marion	Oct. 15, 1961	[a]13
		Wash.	Adams	Aug. 1961	6.5
	2	Wyo.	Platte	Aug. 1961	9.4
	3	Okla.	Blaine	June 1961	21
			McClain	May 1961	31
	6	Ill.	Whiteside	July 10, 1961	31
Wheat					
bran	11	N. Y.	Niagara	Aug. 1, 1961	23
			Yates	Aug. 1, 1961	64
		Pa.	Adams, York	July 1961	80
durum	2	Mont.	Pondera	Aug. 30, 1961	3.3
	4	N. Dak.	Nelson	Sept. 1961	11
flour	11	N. Y.	Niagara	Aug. 1, 1961	4.3
			Yates	Aug. 1, 1961	1.5
		Pa.	Adams, York	July 1961	6.0
spring	1	Ore.	Umatilla	Jan. 25, 1962[c]	[a]2.5
	2	Mont.	Teton	Aug. 15, 1961	6.1
	4	N. Dak.	Emmons	Aug. 15, 1961	14
		S. Dak.	Deuel	Aug. 1961	6.0
winter	1	Ore.	Marion	Aug. 1961	1.8
		Wash.	Adams	Aug. 1961	3.0
			Grant	Sept. 1961	3.2
			Whitman	Aug. 1961	6.1
	3	Okla.	Caddo	June 1961	24
			Garfield	May 1961	21
			Oklahoma	June 1961	21
			Seminole	June 1961	33
	4	N. Dak.	Burleigh	Aug. 1961	9.3
			Kidder	Sept. 15, 1961	17
			Morton	Aug. 15, 1961	14
		S. Dak.	Deuel	Aug. 1961	8.7
			Pennington	July 15, 1960	20
	5	Mich.	Berrien	Aug. 1, 1961	5.5
			Ionia	Aug. 1, 1961	22[d]
			Monroe	July 10, 1961	5.8
	6	Ill.	Carroll	July 15, 1961	39
			Lee	July 1961	18
			Stephenson	July 1961	16

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
	7	Ohio	Clinton	1960	33
			Hancock, Sandusky, Seneca, Wood	July 15, 1961	15
	9	Ga.	Bartow	1960	13
		N. C.	Harnett	July 1961	55
	10	N. J.	Hunterdon	July 1961	20
	11	N. Y.	Niagara	Aug. 1, 1961	15
			Yates	Aug. 1, 1961	12
				Aug. 1, 1961	17
		Pa.	Adams, York	July 1961	23
			Bucks	July 1961	33
			Chester	July 14, 1960	32
			Huntingdon, Mifflin	July 15, 1960	31
			Lancaster	Aug. 1960	20
Dairy products					
Cheese, cheddar	1	Idaho	Bonneville	Mar. 1, 1962	[a]20
		Ore., Wash.		Jan. 1962	[a]38
				Feb. 5, 1962	[a]48
		Wash.		July 1961	63
				Dec. 1960	24
	2	Utah		Jan. 5, 1961	27
				Jan. 31, 1961	48
	4	Minn.	Carver, Mcleod, Sibley		[a]28
				Apr. 16, 1962[d]	[a]28
	6	Ill.		Dec. 1, 1961[d]	[a]53
				Dec. 19, 1961[d]	[a]46
				Jan. 8, 1962[d]	[a]48
				Feb. 8, 1962[d]	[a]48
	7	Ohio		Dec. 31, 1961[d]	[a]59
	11	N. Y.	Erie	Oct. 19, 1961[d]	[a]23
				Nov. 8, 1961[d]	[a]40
Eggs					
shell	4	Minn.		Mar. 6, 1962	[a]390
	5	Mich.	Kalamazoo	Dec. 11, 1961	[a]201
				Feb. 1, 1962	[a]222
substance	4	Minn.		Mar. 5, 1962	[a]1.5
	5	Mich.		Sept. 25, 1961	[a]0.9
			Kalamazoo	Dec. 11, 1961	[a]0.7
				Feb. 1, 1962	[a]1.0
	10	N. J.	Cumberland	Jan. 21, 1962	[a]2.4
Milk					
condensed	11	Pa.		Sept. 15, 1961[d]	24
				Nov. 2, 1961[d]	[a]4.0
evaporated	1	Idaho		Jan. 1961[d]	8.4
	8	La.		Jan. 1961	13
	11	N. Y.		Jan. 19, 1961	51
Fish					
Bonita, canned in oil		Peru		Dec. 11, 1961[b]	[a]0.4
				Dec. 13, 1961[b]	[a]0.0
				Dec. 13, 1961[b]	[a]0.1
				Dec. 13, 1961[b]	[a]1.0
Clams					
fresh	1	Wash.		Jan. 1961	0.4
	12	Mass.		Jan. 1962	[a]0.3
				Mar. 1961	0.9
frozen		Mexico		Dec. 28, 1961[b]	[a]0.5
				Feb. 9, 1962[b]	[a]0.9
razor, frozen	1	Wash.		Mar. 1961	0.2
				Nov. 1961	[a]0.0
Flounder, fillet	12	Mass.		Dec. 8, 1961	[a]0.6
				Jan. 18, 1962	[a]0.3
				Jan. 18, 1962	[a]0.6
Haddock	12	Mass.		Sept. 22, 1961[b]	[a]0.4

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Lobster, frozen	12	Mass.		Jan. 19, 1962	[a]0.4
		Australia		Dec. 4, 1961[b]	[a]0.0
				Mar. 9, 1962[b]	[a]0.2
		Brazil		Dec. 11, 1961[b]	[a]0.6
		Chile		Dec. 7, 1961[b]	[a]0.3
		Denmark		Dec. 8, 1961[b]	[a]0.2
		S. Africa		Nov. 23, 1961[b]	[a]1.5
Oysters, fresh	1	Wash.		Jan. 4, 1962	[a]0.0
				Jan. 5, 1962	[a]0.4
				Jan. 11, 1962	[a]0.1
				Mar. 6, 1962	[a]0.2
	10	Md.		Mar. 16, 1962	[a]0.1
				Mar. 30, 1962	[a]2.7
Salmon, canned		Alaska		June 7, 1961	0.0
				July 10, 1961	0.0
				Dec. 20, 1961	[a]0.5
				Dec. 20, 1961	[a]1.4
Sardines, canned	12	Maine		Sept. 1961	0.4
				Jan. 5, 1962	[a]2.6
		Denmark		Dec. 5, 1961[b]	0.0
		Norway		Feb. 6, 1962[b]	[a]4.2
				Feb. 20, 1962[b]	[a]2.0
		Portugal		Dec. 1, 1961[b]	[a]3.5
				Dec. 8, 1961[b]	[a]8.1
				Jan. 2, 1962[b]	[a]2.6
				Feb. 5, 1962[b]	[a]3.1
Shrimp, frozen	1	Calif.		Oct. 1961	[a]3.0
		Colombia		Dec. 8, 1961[b]	[a]0.8
				Dec. 11, 1961[b]	[a]0.7
		Ecuador		Dec. 8, 1961[b]	[a]0.6
		India		Dec. 8, 1961[b]	[a]0.2
				Dec. 8, 1961[b]	[a]3.1
		Mexico		Dec. 1, 1961[b]	[a]0.1
				Dec. 21, 1961[b]	[a]0.0
		Panama		Dec. 8, 1961[b]	[a]0.0
				Dec. 12, 1961[b]	[a]0.0
				Dec. 12, 1961[b]	[a]0.2
Tuna, canned in brine		Angola		Feb. 2, 1962[b]	[a]0.4
		Japan		Dec. 5, 1961[b]	[a]0.2
				Dec. 6, 1961[b]	0.1
				Dec. 12, 1961[b]	[a]0.0
				Dec. 15, 1961[b]	[a]0.3
				Dec. 22, 1961[b]	[a]0.1
				Jan. 1962[b]	[a]2.8
				Feb. 5, 1962[b]	[a]0.0
				Feb. 12, 1962[b]	[a]0.3
		Peru		Feb. 28, 1962[b]	[a]0.0
		Portugal		Jan. 24, 1962[b]	[a]0.2
Baby foods					
Vegetables, strained					
Carrots	1	Calif.		Sept. 16, 1960[d]	0.4
				Sept. 1, 1961[d]	0.5
	9	N. C.		Oct. 20, 1960[d]	3.9
	11	N. Y.		Nov. 15, 1960[d]	1.8
Potato, sweet	1	Calif.		Sept. 1960[d]	3.4
Squash	5	Mich.		Sept. 15, 1960[d]	2.2
Fruits, strained					
Applesauce	1	Calif.		Sept. 1, 1961[d]	0.4
Banana		Central America		1960[d]	0.3
Pears	1	Calif.		Sept. 1, 1961[d]	1.6
Plums	5	Mich.		Sept. 16, 1960[d]	1.0

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
Cereals					
Barley	5	Mich.		Oct. 13, 1960[d]	8.3
Corn flour	6	Ill.		Feb. 2, 1961[d]	0.3
Hi-Protein	5	Mich.		July 19, 1960[d]	29
				Mar. 8, 1961[d]	24
				Apr. 1961[d]	49
Mixed	5	Mich.		Feb. 2, 1961[d]	3.1
Oat flour	5	Mich.		Dec. 28, 1960[d]	5.4
				Mar. 8, 1961[d]	6.7
	6	Iowa		Nov. 16, 1960[d]	6.8
Oatmeal	5	Mich.		June 24, 1960[d]	25
				Nov. 1960[d]	22
				Apr. 18, 1961[d]	5.8
Rice	5	Mich.		Aug. 25, 1960[d]	3.2
				Nov. 16, 1960[d]	1.7
				Jan. 18, 1961[d]	4.5
	11	Pa.		Oct. 11, 1960[d]	2.6
Beverage products					
Cocoa beans		Brazil		Jan. 11, 1962[b]	[a]8.1
		Dominican Republic		Mar. 7, 1962[b]	[a]36
		Ghana		Jan. 11, 1962[b]	[a]12
Coffee beans		Brazil		Jan. 5, 1961[b]	12
				Nov. 28, 1961[b]	[a]7.4
				Dec. 1961[b]	[a]10
				Dec. 1961[b]	[a]13
				Dec. 11, 1961[b]	[a]9.6
				Jan. 1962[b]	[a]6.0
				Jan. 12, 1962[b]	[a]14
		Cameroons		Dec. 5, 1961[b]	[a]26
				Jan. 25, 1962[b]	[a]23
		Congo		Dec. 5, 1961[b]	[a]30
		Costa Rica		Dec. 4, 1961[b]	[a]1.8
		Ecuador		Feb. 8, 1962[b]	[a]4.1
		Ghana		Jan. 12, 1962[b]	[a]9.0
		Guatemala		Nov. 13, 1961[b]	[a]16
				Dec. 1, 1961[b]	[a]47
				Dec. 4, 1961[b]	[a]41
		Ivory Coast		Jan. 17, 1962[b]	[a]16
				Jan. 17, 1962[b]	[a]17
		Mexico		Jan. 4, 1962[b]	[a]45
				Jan. 17, 1962[b]	[a]25
				Jan. 23, 1962[b]	[a]21
				Jan. 24, 1962[b]	[a]26
		Nigeria		Jan. 1962[b]	[a]9.0
				Jan. 1962[b]	[a]13
				Feb. 5, 1962[b]	[a]32
Tea		British E. Africa		Feb. 26, 1962[b]	[a]47
				Mar. 6, 1962[b]	[a]41
		Ceylon		Feb. 21, 1962[b]	[a]320
				Mar. 12, 1962[b]	[a]183
				Mar. 16, 1962[b]	[a]222
				Mar. 19, 1962[b]	[a]245
		Formosa		Dec. 21, 1961[b]	[a]294
		Hong Kong		Nov. 1, 1961[b]	[a]236
		India		Feb. 12, 1962[b]	[a]148
				Feb. 26, 1962[b]	[a]179
				Mar. 6, 1962[b]	[a]1053
				Mar. 12, 1962[b]	[a]160
				Mar. 12, 1962[b]	[a]466
				Mar. 15, 1962[b]	[a]244
		Indonesia		Feb. 19, 1962[b]	[a]110
				Mar. 5, 1962[b]	[a]213
				Mar. 13, 1962[b]	[a]20
				Apr. 3, 1962[b]	[a]260

See p. 321 for footnotes.

TABLE 2.—STRONTIUM-90 CONTENT OF VARIOUS FOODS—Continued

Food	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State or country	County		
		Japan		Dec. 21, 1961[b]	[a]192
				Jan. 30, 1962[b]	[a]215
				Jan. 31, 1962[b]	[a]352
		Kenya-Uganda		Mar. 14, 1962[b]	[a]56
				Mar. 14, 1962[b]	[a]61
Nuts					
Brazil		Bolivia		Dec. 11, 1961[b]	[a]77
				Dec. 4, 1961[b]	[a]45
		Brazil		Dec. 5, 1961[b]	[a]43
				Dec. 7, 1961[b]	[a]77
				Dec. 11, 1961[b]	[a]63
				Dec. 12, 1961[b]	[a]47
Cashew		India		June 1961[b]	1.3
				June 9, 1961[b]	1.3
				Dec. 4, 1961[b]	[a]1.5
				Dec. 4, 1961[b]	[a]1.6
				Dec. 12, 1961[b]	[a]0.7
		Mozambique		Feb. 12, 1962[b]	[a]0.0
Peanuts	3	Okla.	Caddo	Sept. 1961	58
	8	Ala.	Covington	Dec. 6, 1961	[a]57
			Houston	Dec. 6, 1961	[a]50
			Pike	Dec. 7, 1961	[a]53
	9	Ga.	Crisp	Sept. 1961	27
			Tift	Oct. 1961	[a]30
		N. C.	Halifax	Mar. 13, 1962	[a]19
Pecans	9	Ga.	Mitchell	Nov. 1961	[a]5.5
			Thomas	Nov. 1961	[a]4.7
Walnuts	1	Calif.	Riverside	Nov. 1961	[a]0.8
			Ventura	Oct. 15, 1961	[a]1.1
				Nov. 1961	[a]0.0
		Ore.	Marion	Oct. 1961	[a]5.7
Miscellaneous					
Caraway seed		Netherlands		Dec. 4, 1961[b]	[a]77
				Dec. 5, 1961[b]	[a]84
				Dec. 14, 1961[b]	[a]115
				Jan. 9, 1962[b]	[a]79
Ginger		Cuba (probably China)		Dec. 11, 1961[b]	[a]1.1
Hops	1	Ore.	Marion	Aug. 15, 1961	13
		Wash.	Yakima	Aug. 1961	56

See p. 321 for footnotes.

tent of some food items, while table 2 presents raw data on strontium–90 content of various foods. Dates in table 2 refer to the dates of harvest or collection, with all products indicated as harvested before or after September 15, 1961, which is the date of arrival of fallout in the U.S. from the U.S.S.R. nuclear testing series. Regional groupings of states of origin which appear in table 2 are arbitrarily numbered according to the schedule below.

1. Pacific—California, Idaho, Nevada, Oregon, Washington
2. Rocky Mountain—Colorado, Montana, Wyoming, Utah
3. Southwestern—Arizona, New Mexico, Oklahoma, Texas
4. North Central—Kansas, Minnesota, Nebraska, North Dakota, South Dakota,
5. Great Lakes—Michigan, Wisconsin
6. Mid Central—Arkansas, Illinois, Iowa, Missouri
7. East Central—Indiana, Kentucky, Ohio
8. South Central—Alabama, Louisiana, Mississippi, Tennessee
9. Southeastern—Florida, Georgia, North Carolina, South Carolina
10. Mid Atlantic—Delaware, Maryland, New Jersey, Virginia, West Virginia
11. Mid Eastern—New York, Pennsylvania
12. New England—Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

Summary

In general, the appearance of strontium–90 contamination associated with 1961 nuclear weapons testing is becoming more marked in those samples harvested in the first quarter of 1962 than in those harvested in the fourth quarter of 1961. Products harvested in the spring and early summer of 1962 can be expected to show increased amounts of contamination.

REFERENCE:

(*1*) U.S. Atomic Energy Commission, *HASL Manual of Standard Procedures*, NYO–4700, Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C. (February 1960), Price $1.75.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1958 and 1959	*May 1960*
1958, 1959, and 1960	*January 1961*
1960	*August 1961*
1959 and 1960	*September 1961*
1958, 1959, 1960, and 1961	*December 1961*
1960 and 1961	*April 1962*
1961	*June 1962*
1960, 1961, and 1962	*August 1962*

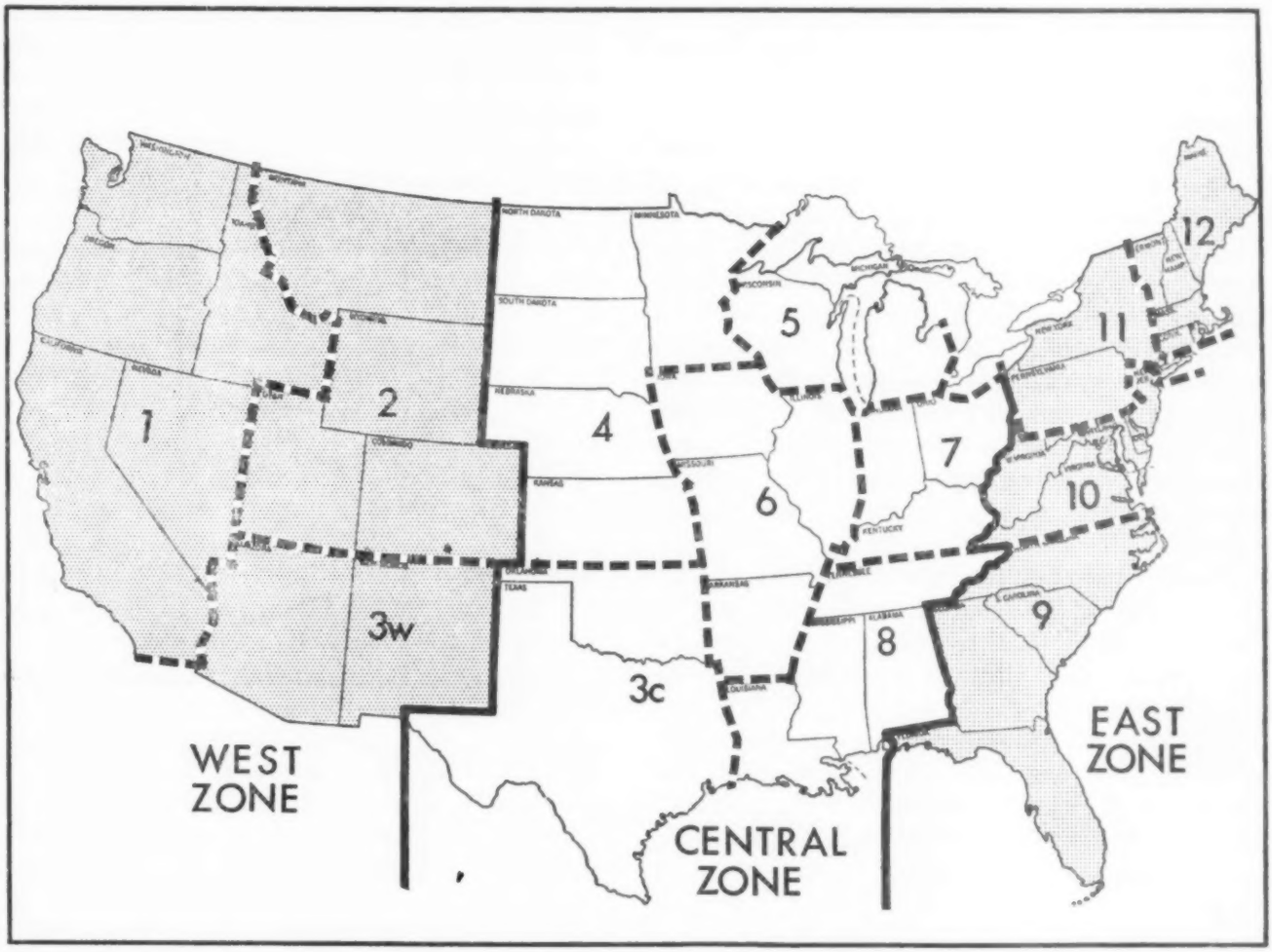


FIGURE 1.—HARVEST REGIONS AND ZONES

Tri-City Diet Study*

November 1961–February 1962

Joseph Rivera
Health and Safety Laboratory, U.S. Atomic Energy Commission

Approximately every 3 months since May 1960, estimates of the strontium–90 content of average diets for individuals living in New York City, San Francisco, and Chicago have been made by the Health and Safety Laboratory.

Selected foods, representing 19 food categories, are purchased at each of these 3 cities about every 3 months and are analyzed for strontium–90. Using data from the U.S. Department of Agriculture, "Household Food Survey of 1955," the annual consumption by an individual can be grouped into the same 19 food categories. The annual dietary intake of strontium–90 and calcium can then be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general. Hence, in the tables that follow, the values shown for food consumption may not be directly related to the original data in the source document.

The consumption data from the "Household Food Survey of 1955" are based on a weight as purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree, as if for actual consumption; for example, fruits are peeled, eggs are shelled, and poultry is de-boned. Therefore, the concentration of radioactivity in foods as reported in the Tri-City Diet Study is based on the trimmed weight. No correction is made for the wasted food. Contributions of strontium–90 from tap water are not included in table 1, but measurements during 1960 and 1961 indicate that the contribution would be in the range of 100 to 200 μμc strontium–90 per year. It is assumed in making this estimate that the average daily intake of tap water is 1.2 liters.

Results obtained from the seventh sampling of foods (November 1961–February 1962) are presented in table 1. The variation with time of the daily intake of strontium–90 at the 3 cities is plotted in figure 1.

The previously noted geographic pattern of distribution of strontium–90 in foods is seen to persist in this last sampling. New York City has the highest levels of dietary strontium–90 contamination, San Francisco has the lowest levels, while Chicago has intermediate levels. Milk continues to be the predominant source of strontium–90 in the diet because of its high annual consumption.

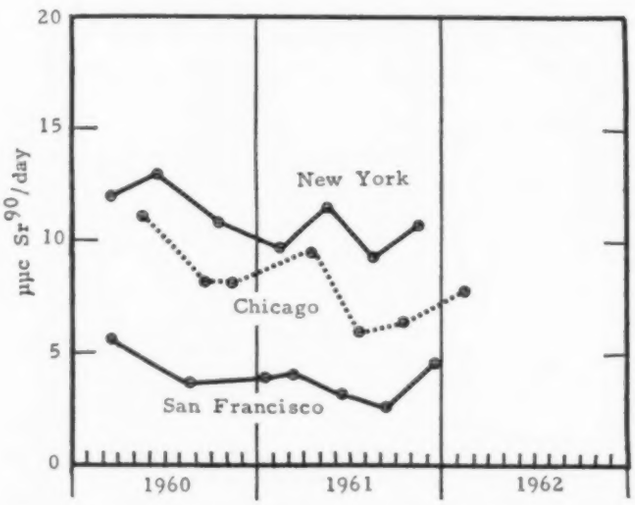


FIGURE 1.—DAILY INTAKE OF STRONTIUM–90 IN TRI-CITY TOTAL DIETS

There is a marked increase in the estimated strontium–90 intake noted in the seventh sampling. This increase is probably due to the contamination of foods resulting from fallout from the October 1961 U.S.S.R. test series. There are insufficient data available at this time to quantitate the contribution of the debris to the strontium–90 levels in U.S. foods exactly. Preliminary measurements of strontium–89 in milk and flour, however, indicate that roughly 5 to 10 percent of the strontium–90 found in milk purchased in the seventh sampling came from the U.S.S.R. test series, while roughly 30 to 50 percent of the strontium–90 in flour was of this origin. It is difficult to understand how

* Data from *Quarterly Summary Report, HASL 127*, July 1, 1962.

TABLE 1.—STRONTIUM–90 LEVELS OF DIET—SEVENTH SAMPLING

Food type	Annual consumption	New York City November 1961		Chicago February 1962		San Francisco December 1961	
	(kg/yr)	μμc/kg	μμc/yr	μμc/kg	μμc/yr	μμc/kg	μμc/yr
Whole grain products	11	9.6	105	7.7	85	3.9	43
Refined grain products	37	6.4	236	6.6	243	6.9	254
Refined grain flour	43	5.0	215	7.3	313	1.7	72
Milk, liquid	221	7.9	1755	4.6	1017	2.3	499
Potatoes	45	5.6	253	7.3	330	1.6	72
Macaroni	3	4.4	13	3.1	9	0.6	2
Beans, dried	3	7.8	23	22.9	69	11.7	35
Vegetables, canned	20	12.3	246	3.7	74	1.3	27
Vegetables, fresh	43	4.4	188	6.1	264	5.5	238
Vegetables, root	17	7.0	120	4.3	74	4.7	81
Fruit, canned	26	1.3*	34*	2.0	51	0.8	20
Fruit juices	19	4.2	80	2.4	46	1.7	33
Fruit, fresh	68	6.5	443	1.5	104	2.2	118
Rice	3	2.6	8	2.0	6	0.6	2
Eggs	16	1.5	24	2.0	32	0.9	14
Fish, fresh	8	0.6*	5*	1.2	9	0.2	1
Fish, shell	1	1.8	2	0.4	0	0.9	1
Meat	73	0.6	43	1.2	86	0.5	36
Poultry	17	3.7	62	0.4	7	0.4	7
Total annual intake	674	—	3855	—	2819	—	1590

* Estimated from sixth sampling.

flour could have been contaminated with fresh fallout so quickly, since it was presumably made of wheat grown prior to the U.S.S.R. tests. When data on the strontium–89 content of foods from the spring sampling are available, it is hoped that this anomaly will be resolved. It should then be possible to make more precise estimates of the contribution of the U.S.S.R. test series to the strontium–90 content of the tri-city diets.

Using the totals given in table 1, the following average concentrations, in μμc Sr^{90}/gm Ca, may be expressed in units of annual intake: New York, 10.1; Chicago, 7.8; San Francisco, 4.2. This calculation was based on calcium data obtained from the first two sampling periods. Despite the fact that there is some variability in the results obtained from analyses of individual food categories, the total intake of calcium was calculated to be 383 grams per person per year, with a standard deviation of less than 5 percent. Because of the relative constancy of the average annual intake of calcium, due to its strong dependence on the relatively constant calcium content of milk, analyses of food categories other than milk for calcium were discontinued after the second sampling.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
First sampling (March–May 1960)	*April 1961*
Second sampling (June–September 1960)	*June 1961*
Third sampling (October 1960–January 1961)	*October 1961*
Fourth sampling (February–April 1961)	*December 1961*
Fifth sampling (May–July 1961)	*March 1962*
Sixth sampling (August–October 1961)	*June 1962*

SECTION III.—MILK

Radionuclide Analyses of Pasteurized Milk

PASTEURIZED MILK MONITORING PROGRAM
April and May 1962

Division of Radiological Health, and
Division of Environmental Engineering & Food Protection,
Public Health Service

Milk monitoring has been conducted by the Public Health Service since early 1957, when the first program was established to develop suitable sampling methods and radiochemical analytical procedures. Raw milk was initially selected for investigation. During this program, it became evident that a broader sampling program was necessary—one more directly related to the milk consumed by the population. The result was the initiation, in the first quarter of 1960, of a pasteurized milk sampling program designed to provide data representative of the milk consumed in selected municipalities. Both programs were reported concurrently until June 1961 to permit comparison of the differences between the earlier, limited, milkshed sampling results and those of the new program.

The June 1961 raw milk sampling results, reported in the November 1961 *Radiological Health Data (RHD)*, represent the last regular publication of such data. A summary discussion of the raw milk sampling program in the December 1961 *RHD* presented the gross relationship between fallout and the occurrence of fission products in milk determined from this study.

During April and May 1962, the surveillance of pasteurized milk was conducted at 61 stations, with the cooperation of State and local milk sanitation agencies who have been shipping samples to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analysis (see figure 1). Publication in *RHD* follows about 3½ months after sample collection because of time required for shipment, processing, decay-product buildup, data compilation, and publication procedures.

The current program emphasizes (1) measurement of the concentrations of radioactivity in samples of pasteurized milk consumed by the public in various regions of the country, and (2) provision of at least one sampling point within virtually all states and additional points when indicated by widely varying conditions of the milk supply or the need to cover large population groups. Each sample is composited in proportion to the volume of milk sold by those plants supplying not less than 90 percent

FIGURE 1.—PASTEURIZED MILK SAMPLING STATIONS, MAY 1962

of a city's milk supply. Prior to September 15, 1961, this composite sample was taken from one day's sales per month and was as representative of a community's total supply as could be achieved under practical conditions. Since September 15, the sampling schedule has been accelerated.

During April 1962, sampling on a weekly basis was performed at most stations. Following the appearance of iodine–131 in pasteurized milk from mid-western states beginning on May 13, a readjustment of the sampling schedule to a semi-weekly basis was made for several stations in this area. For a more detailed discussion of the iodine–131 appearance, see "Mid-May Iodine–131 in the Midwest," Section V, page 350. All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention and adjustment in the pasteurized milk monitoring.

Iodine–131, cesium–137, and barium–140 are determined by gamma scintillation spectroscopy, while strontium–89 and strontium–90 are determined following radiochemical separation. The minimum detectable concentrations in units of $\mu\mu c$/liter are: Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Strontium–90 Profile

In the previous 4 issues, *RHD* published graphical presentations of the average monthly concentrations of strontium–90 in pasteurized milk from 36 selected cities from the monitoring program (see table 2 for publication month). An additional 16 cities are similarly represented in figure 2. Each graph shows the strontium–90 concentrations in milk from selected cities in the 4 major geographic regions* of the United States. Regional differences can be seen in these graphs. In most cases the West has had the lowest strontium–90 concentrations during the past two years. The South had the highest values, while the Northeast and North Central have been in the middle range.

* These regions correspond to those used by the U.S. Department of Agriculture for their tabulations of average "per person" quantities of food consumed per week, as presented in the August, September, and October 1960 *RHD*.

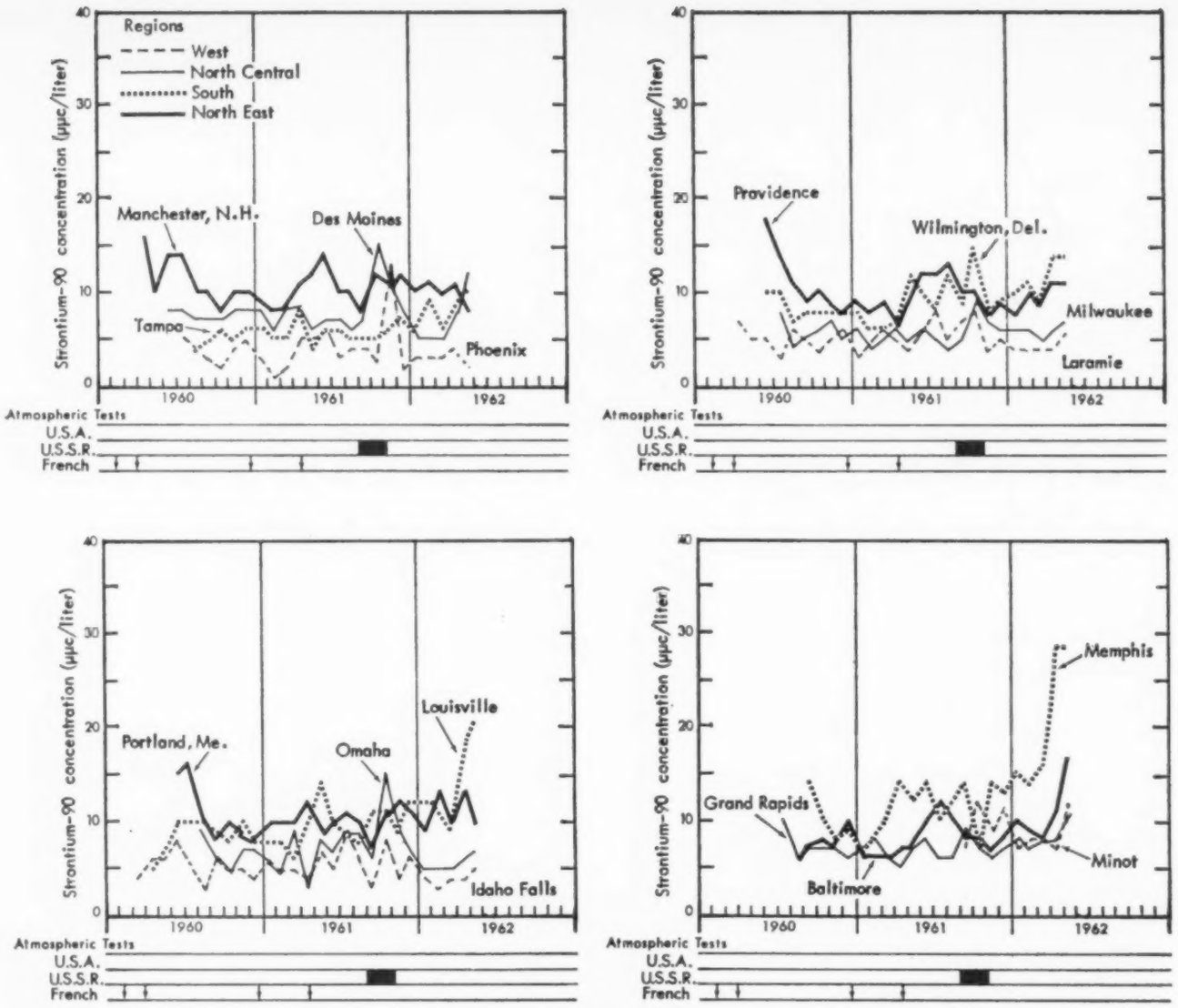


FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN MILK FROM SELECTED CITIES IN THE 4 MAJOR GEOGRAPHIC REGIONS OF THE UNITED STATES

Strontium–90 and Strontium–89 Geographical Distribution

Figure 3 geographically generalizes the strontium–90 and strontium–89 concentrations during April and May 1962 by means of concentration contours. It must be remembered when interpreting these plots that they are based on concentrations in pasteurized milk representing milk sold in 61 cities distributed throughout the United States. Thus, intervening milk sheds for smaller cities and their effect on intra and interstate milk distribution patterns are not taken into consideration. This distribution of cities allows concentration contours to be reasonably used for graphically presenting this data. The pattern in evidence during the winter months of December, January, February, and March has changed during April and May. A general nationwide increase in strontium–90 concentration is apparent beginning in April and continuing during May. Nationwide strontium–89 concentration continued to increase during April with the highest concentrations in the South. In May, though, this upward trend of strontium–89 reversed itself in the South, aparently due to the natural radioactive decay of the strontium–89 (half life, 51 days). In the North, strontium–89 concentrations had been relatively low due to the practice of feeding cattle during the winter on silage harvested prior to the resumption of atmospheric nuclear weapons testing. During

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, APRIL 1962

[Average radioactivity concentrations in $\mu\mu c$/liter]

Area		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
City	State	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month
Montgomery	Ala.	1.14	1.21	40	170	12	23	<10	<10	20	55	20	40
Palmer	Alaska	1.05	1.11	5	15	6	6	<10	<10	10	<5	<10	10
Phoenix	Ariz.	1.05	1.08	25	20	3	3	<10	<10	5	<5	<10	<10
Little Rock	Ark.	1.18	1.14	105	380	22	40	<10	<10	25	120	20	40
Sacramento	Calif.	1.07	1.09	15	45	3	6	<10	<10	5	10	<10	<10
San Francisco	Calif.	1.10	1.13	40	80	5	10	10	10	10	20	<10	20
Denver	Colo.	1.07	1.15	10	10	5	6	<10	<10	10	<5	<10	10
Hartford	Conn.	1.14	1.16	<5	5	9	10	<10	<10	5	10	<10	<10
Wilmington	Del.	1.17	1.20	5	55	10	14	<10	<10	5	20	<10	<10
Washington	D. C.	1.16	1.16	<5	40	8	12	<10	<10	<5	25	<10	<10
Tampa	Fla.	1.22	1.21	20	30	7	9	<10	<10	55	90	<10	<10
Atlanta	Ga.	1.19	1.23	120	175	13	25	<10	<10	30	85	20	20
Honolulu	Hawaii	1.04	1.10	50	40	5	6	10	<10	10	15	<10	<10
Idaho Falls	Idaho	1.07	1.07	<5	5	4	4	10	<10	5	<5	<10	20
Chicago	Ill.	1.13	1.14	<5	<5	6	7	<10	<10	<5	5	<10	<10
Indianapolis	Ind.	1.20	1.20	10	30	9	12	<10	<10	5	15	<10	<10
Des Moines	Iowa	1.07	1.09	5	30	5	8	<10	<10	10	5	<10	10
Wichita	Kans.	1.07	1.07	20	35	7	8	<10	<10	5	5	<10	10
Louisville	Ky.	1.17	1.16	20	110	11	18	<10	<10	10	25	<10	<10
New Orleans	La.	1.22	1.22	325	285	28	40	<10	<10	70	135	50	30
Portland	Maine	1.20	1.15	<5	<5	11	13	<10	<10	15	20	<10	<10
Baltimore	Md.	1.17	1.18	<5	30	9	11	<10	<10	5	20	<10	<10
Boston	Mass.	1.19	1.18	<5	<5	10	12	<10	<10	15	10	<10	<10
Detroit	Mich.	1.16	1.15	<5	5	6	8	<10	<10	<5	5	<10	<10
Grand Rapids	Mich.	1.19	1.23	<5	<5	8	8	<10	<10	10	10	<10	<10
Minneapolis	Minn.	1.07	1.09	5	5	6	5	10	<10	10	<5	<10	10
Jackson	Miss.	1.27	1.26	245	340	23	37	<10	<10	40	90	40	40
Kansas City	Mo.	1.05	1.07	15	60	7	11	10	<10	10	<5	<10	20
St. Louis	Mo.	1.07	1.07	10	40	8	10	<10	<10	10	5	10	10
Helena	Mont.	1.08	1.05	5	20	4	4	20	<10	<5	<5	<10	20
Omaha	Nebr.	1.09	1.14	10	30	5	6	<10	<10	5	<5	<10	10
Manchester	N. H.	1.17	1.18	<5	<5	10	11	<10	<10	25	25	<10	<10
Trenton	N. J.	1.16	1.13	<5	20	8	8	<10	<10	5	10	<10	<10
Albuquerque	N. Mex.	1.07	1.10	10	20	4	3	20	10	<5	5	10	20
Buffalo	N. Y.	1.13	1.15	<5	<5	8	8	<10	<10	5	5	<10	<10
New York	N. Y.	1.13	1.14	<5	<5	9	9	<10	<10	<5	5	<10	<10
Syracuse	N. Y.	1.14	1.14	<5	<5	7	8	<10	<10	5	10	<10	<10
Charlotte	N. C.	1.20	1.24	25	125	12	17	<10	<10	<5	50	<10	<10
Minot	N. D.	1.04	1.08	<5	5	8	7	<10	<10	10	5	<10	10
Cincinnati	Ohio	1.18	1.16	15	60	10	14	<10	<10	<5	20	<10	<10
Cleveland	Ohio	1.16	1.17	<5	<5	8	9	<10	<10	5	5	<10	<10
Oklahoma City	Okla.	1.17	1.18	40	95	9	16	<10	<10	<5	20	<10	10
Portland	Ore.	1.08	1.10	25	80	7	12	<10	<10	15	30	<10	20
Philadelphia	Pa.	1.16	1.16	<5	20	9	11	<10	<10	<5	15	<10	<10
Pittsburgh	Pa.	1.17	1.19	<5	10	11	11	<10	<10	<5	10	<10	<10
San Juan	P. R.	1.14	1.14	110	115	8	12	<10	<10	25	60	20	20
Providence	R. I.	1.16	1.16	<5	5	9	11	<10	<10	10	15	<10	<10
Charleston	S. C.	1.22	1.20	80	145	14	23	<10	<10	25	75	10	20
Rapid City	S. D.	1.09	1.05	10	10	6	7	10	<10	15	<5	10	20
Chattanooga	Tenn.	1.24	1.24	110	340	15	29	<10	<10	20	110	20	40
Memphis	Tenn.	1.21	1.20	120	240	15	28	<10	<10	<5	45	20	40
Austin	Tex.	1.16	1.16	25	45	5	8	<10	<10	<5	15	<10	<10
Dallas	Tex.	1.21	1.20	55	160	10	17	<10	<10	5	50	<10	20
Salt Lake City	Utah	1.08	1.10	<5	5	4	4	10	<10	5	<5	<10	<10
Burlington	Vt.	1.16	1.18	<5	<5	7	8	<10	<10	10	10	<10	<10
Norfolk	Va.	1.22	1.18	20	75	11	12	<10	<10	5	30	<10	<10
Seattle	Wash.	1.07	1.08	15	50	6	10	<10	<10	15	20	<10	10
Spokane	Wash.	1.07	1.14	<5	20	6	7	10	<10	10	10	<10	<10
Charleston	W. Va.	1.15	1.17	10	35	9	12	<10	<10	<5	10	<10	<10
Milwaukee	Wis.	1.20	1.21	<5	<5	6	6	<10	<10	5	5	<10	<10
Laramie	Wyo.	1.05	1.08	<5	10	4	4	10	<10	10	5	<10	10
Network average		1.14	1.15	30	63	8.7	12.0	<10	<10	11	25	<10	10

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, MAY 1962

[Average radioactivity concentrations in μμc/liter]

Area		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140		Sr^{90} profile in *RHD*
City	State	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	First quarter	Avg. for month	
Montgomery	Ala	1.14	1.19	40	90	12	17	<10	20	20	65	20	10	
Palmer	Alaska	1.05	1.09	5	40	6	8	<10	<10	10	25	<10	<10	
Phoenix	Ariz	1.05	1.06	25	10	3	2	<10	<10	5	10	<10	<10	Sept 62
Little Rock	Ark	1.18	1.18	105	180	22	40	<10	20	25	80	20	40	July 62
Sacramento	Calif	1.07	1.07	15	30	3	5	<10	20	5	20	<10	<10	Aug 62
San Francisco	Calif	1.10	1.12	40	60	5	9	10	<10	10	20	<10	<10	May 62
Denver	Colo	1.07	1.15	10	20	5	6	<10	10	10	5	<10	<10	Aug 62
Hartford	Conn	1.14	1.18	<5	10	9	9	<10	<10	5	30	<10	<10	Aug 62
Wilmington	Del	1.17	1.17	5	50	10	14	<10	<10	5	45	<10	<10	Sept 62
Washington	D. C	1.16	1.16	<5	50	8	15	<10	<10	<5	35	<10	10	
Tampa	Fla	1.22	1.21	20	25	7	10	<10	<10	55	110	<10	<10	Sept 62
Atlanta	Ga	1.19	1.19	120	115	13	20	<10	10	30	85	20	20	May 62
Honolulu	Hawaii	1.04	1.05	50	30	5	5	10	10	10	30	<10	10	
Idaho Falls	Idaho	1.07	1.07	<5	[a]15	4	5	10	<10	5	10	<10	<10	Sept 62
Chicago	Ill	1.13	1.14	<5	30	6	12	<10	40	<5	20	<10	20	May 62
Indianapolis	Ind	1.20	1.18	10	55	9	18	<10	10	5	50	<10	20	Aug 62
Des Moines	Iowa	1.07	1.06	5	90	5	12	<10	90	10	30	<10	30	Sept 62
Wichita	Kans	1.07	1.08	20	85	7	11	<10	220	5	20	<10	20	July 62
Louisville	Ky	1.17	1.20	20	110	11	21	<10	20	10	35	<10	10	Sept 62
New Orleans	La	1.22	1.24	325	220	28	34	<10	<10	70	155	50	30	June 62
Portland	Maine	1.20	1.26	<5	10	11	10	<10	<10	15	40	<10	<10	Sept 62
Baltimore	Md	1.17	1.17	<5	45	9	17	<10	20	5	55	<10	<10	Sept 62
Boston	Mass	1.19	1.18	<5	15	10	12	<10	<10	15	40	<10	<10	June 62
Detroit	Mich	1.16	1.18	<5	25	6	10	<10	10	<5	25	<10	<10	Aug 62
Grand Rapids	Mich	1.19	1.25	<5	20	8	11	<10	<10	10	20	<10	<10	Sept 62
Minneapolis	Minn	1.07	1.06	5	55	6	11	10	120	10	20	<10	20	June 62
Jackson	Miss	1.27	1.27	245	175	23	33	<10	<10	40	85	40	30	Aug 62
Kansas City	Mo	1.05	1.08	15	120	7	17	10	200	10	30	<10	50	Aug 62
St. Louis	Mo	1.07	1.06	10	100	8	14	<10	30	10	30	10	10	June 62
Helena	Mont	1.08	1.10	5	45	4	11	20	10	<5	25	<10	<10	July 62
Omaha	Nebr	1.09	1.16	10	40	5	8	<10	30	5	10	<10	<10	Sept 62
Manchester	N. H	1.17	1.20	<5	10	10	8	<10	<10	25	45	<10	<10	Sept 62
Trenton	N. J	1.16	1.16	<5	25	8	11	<10	<10	5	15	<10	<10	Aug 62
Albuquerque	N. Mex	1.07	1.08	10	10	4	3	20	20	<5	5	10	10	July 62
Buffalo	N. Y	1.13	1.21	<5	15	8	8	<10	<10	5	30	<10	<10	Aug 62
New York	N. Y	1.13	1.12	<5	20	9	14	<10	20	<5	30	<10	<10	May 62
Syracuse	N. Y	1.14	1.16	<5	20	7	10	<10	20	5	20	<10	<10	July 62
Charlotte	N. C	1.20	1.20	25	70	12	22	<10	<10	<5	40	<10	20	July 62
Minot	N. D	1.04	1.12	<5	60	8	12	<10	20	10	20	<10	<10	Sept 62
Cincinnati	Ohio	1.18	1.18	15	70	10	19	<10	20	<5	25	<10	20	Aug 62
Cleveland	Ohio	1.16	1.14	<5	45	8	10	<10	<10	5	20	<10	<10	July 62
Oklahoma City	Okla	1.17	1.14	40	115	9	19	<10	20	<5	60	<10	20	
Portland	Ore	1.08	1.14	25	135	7	24	<10	<10	15	70	<10	<10	Aug 62
Philadelphia	Pa	1.16	1.16	<5	40	9	15	<10	<10	<5	40	<10	<10	July 62
Pittsburgh	Pa	1.17	1.15	<5	35	11	13	<10	<10	<5	30	<10	<10	June 62
San Juan	P. R	1.14	1.11	110	60	8	8	<10	20	25	50	20	20	
Providence	R. I	1.16	1.18	<5	20	9	11	<10	20	10	40	<10	<10	Sept 62
Charleston	S. C	1.22	1.21	80	85	14	19	<10	<10	25	65	10	20	Aug 62
Rapid City	S. D	1.09	1.03	10	10	6	4	10	<10	15	<5	10	<10	
Chattanooga	Tenn	1.24	1.26	110	160	15	32	<10	20	30	85	20	20	
Memphis	Tenn	1.21	1.23	120	125	15	28	<10	<10	<5	35	20	20	Sept 62
Austin	Tex	1.16	1.20	25	30	5	8	<10	<10	<5	20	<10	<10	June 62
Dallas	Tex	1.21	1.16	55	95	10	20	<10	20	5	50	<10	20	Aug 62
Salt Lake City	Utah	1.08	1.11	<5	35	4	7	10	<10	5	20	<10	<10	June 62
Burlington	Vt	1.16	1.11	<5	10	7	8	<10	<10	10	30	<10	<10	Aug 62
Norfolk	Va	1.22	1.20	20	60	11	18	<10	10	5	50	<10	10	Aug 62
Seattle	Wash	1.07	1.12	15	130	6	24	<10	<10	15	70	<10	<10	June 62
Spokane	Wash	1.07	1 14	<5	80	6	16	10	<10	10	35	<10	<10	Aug 62
Charleston	W. Va	1.15	1.20	10	95	9	20	<10	20	<5	40	<10	20	
Milwaukee	Wis	1.20	1.22	<5	5	6	7	<10	10	5	15	<10	<10	Sept 62
Laramie	Wyo	1.05	1.08	<5	25	4	6	10	20	10	15	<10	10	Sept 62
Network average		1.14	1.15	30	60	8.7	13.9	<10	21	11	38	<10	12	

[a] Average based on two months.

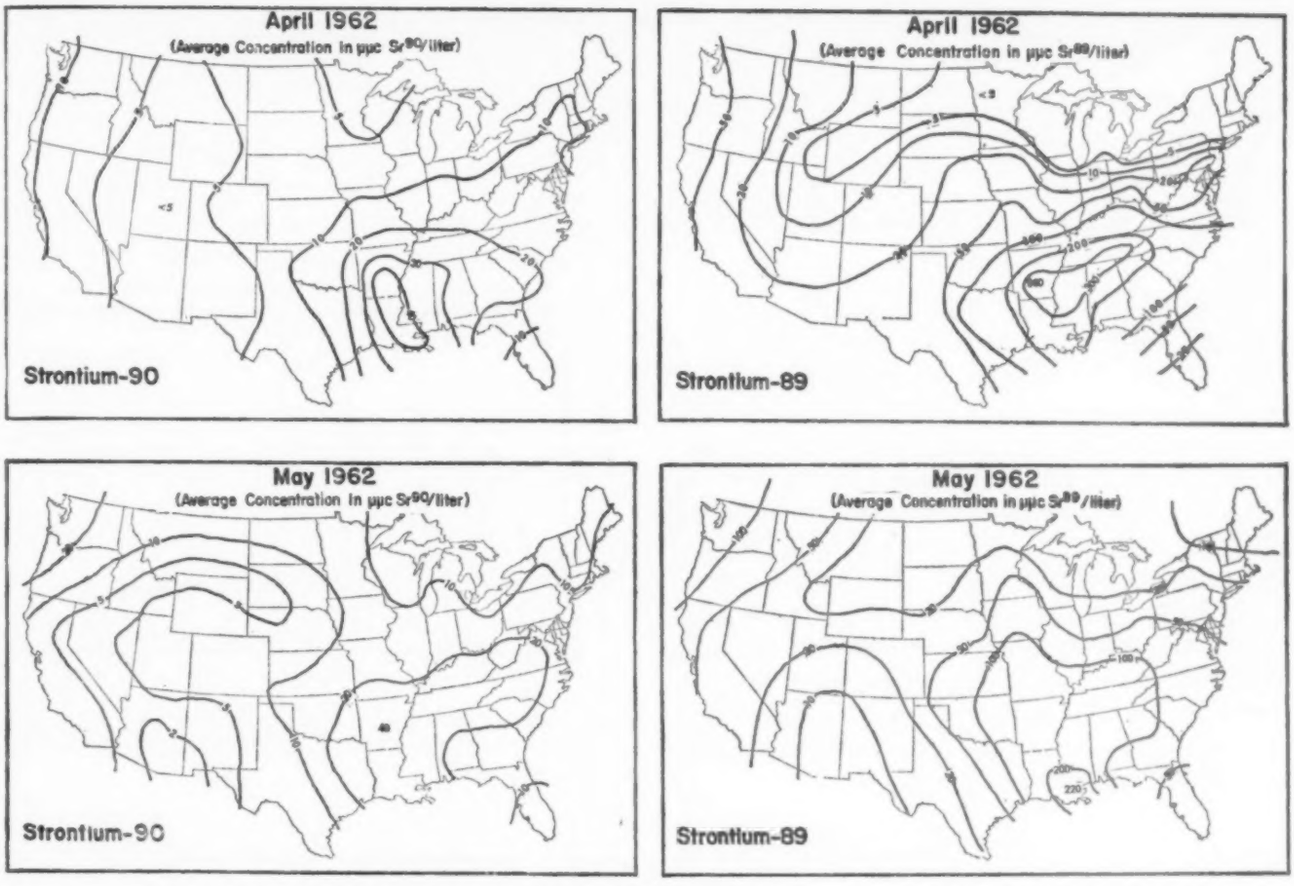


FIGURE 3.—GEOGRAPHICAL DISTRIBUTION OF STRONTIUM-90 AND STRONTIUM-89 CONCENTRATIONS DURING APRIL AND MAY 1962

May, however, the concentrations increased as the dairy cattle began to feed on pasture contaminated with relatively fresh fission products.

In April, iodine–131 concentrations in milk were less than the minimum detectable concentration. Iodine–131 concentrations increased to a maximum monthly average of 220 μμc/liter during May at Wichita, Kansas.

Tables 1 and 2 present summaries of all available analyses for April and May 1962. When a radionuclide is reported by the laboratory as being below the minimum detectable concentration, one-half of this value is used for calculating the monthly average. A similar procedure is used for the network average.

Strontium–90 in Canadian Dried Milk Products

RADIOACTIVE FALLOUT STUDY PROGRAM
Fourth Quarter 1961

Department of National Health and Welfare, Ottawa, Canada

In November 1955, radiochemical analyses of skim milk and buttermilk powders for strontium–90 concentrations were initiated by the Department of National Health and Welfare. Through the cooperation of the Marketing Division of the Canadian Department of Agriculture, dairy products inspectors collected four 1-pound samples of dried milk each month from each station (see figure 1) for the Radioactive Fallout Study Program. No precise control is maintained over the method of sample collection. Whether or not all samples are collected on the same day or if the sample is truly representative of the milk produced in a given area is not known.

FIGURE 1.—CANADIAN DRIED MILK SAMPLING STATIONS

Because of uncertainties introduced by the method of sampling, the significance of differences between results from station-to-station and month-to-month cannot be precisely determined. It is possible, however, to consider all the results for a given period of time as being sufficiently random in selection to show any national trend when average values for such periods and all stations are plotted. These data are plotted in figure 2. It should be emphasized that average concentrations over a considerable period of time are more meaningful from the public health point of view than fluctuating monthly concentrations.

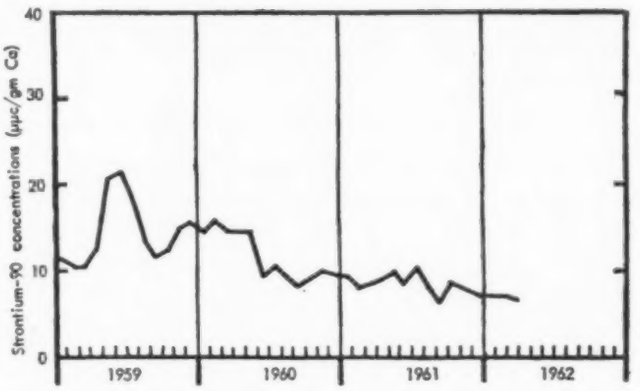


FIGURE 2.—AVERAGE STRONTIUM–90 CONCENTRATIONS IN CANADIAN DRIED MILK PRODUCTS

A detailed discussion of the sampling and radiochemical methodology employed may be found in the Department's publication (*1*).

Table 1 presents the results of measurements of strontium–90 in Canadian dried milk powder for the fourth quarter of 1961. This table was

TABLE 1.—STRONTIUM–90 IN CANADIAN DRIED MILK POWDER, 1961

[Concentrations in μμc/g Ca]

Station	Type of milk	October	November	December
Calgary	Skim milk	6.2	7.7	5.5
Chicoutimi [1]	Skim milk	13.3	[2] NS	NS
E. Florenceville	Skim milk	11.9	11.5	NS
Edmonton	Skim milk	6.9	5.9	6.8
Granby	Skim milk	12.4	9.4	11.7
Halifax	Skim milk	8.0	9.4	8.8
La Durantye	Skim milk	17.6	9.9	9.5
London	Skim milk	2.5	3.6	3.3
Megantic	Skim milk	11.7	10.8	12.3
Moncton	Buttermilk	7.2	10.9	8.4
Ottawa	Skim milk	4.3	4.8	5.0
Saskatoon	Buttermilk	5.1	6.5	6.1
Sussex	Skim milk	8.3	9.2	7.9
Vancouver	Skim milk	11.7	9.6	10.1
Walkerton	Skim milk	4.0	3.7	4.4
Winnipeg	Buttermilk	5.6	5.0	4.1
Average		8.5	7.9	7.3

[1] Chicoutimi stopped production. Milk powder samples from Mistassini on opposite shore of Lac St. Jean.
[2] NS indicates no sample received for the month.

taken from the "Quarterly Report of the Radioactive Fallout Monitoring Program," dated May 1962, published by the Radiation Protection Division of the Department of National Health and Welfare. [*Editor's note: For an approximate method to compare the Canadian powdered milk data in units of μμc/gm Ca to other milk data in units of μμc/liter, it can be assumed that milk has approximately 1 g Ca/liter of liquid milk. Therefore, the two units are roughly interchangeable.*]

Previous coverage in *Radiological Health Data:*

Period	*Issue*
January 1956–March 1960	*September 1960*
Second quarter 1960	*December 1960*
Third quarter 1960	*April 1961*
Fourth quarter 1960	*August 1961*
First quarter 1961	*December 1961*
Second quarter 1961	*February 1962*
Third quarter 1961	*May 1962*

REFERENCE

(*1*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada, "Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples," *CNHW (RP–1)*, (July 1958).

Radiostrontium in Milk[1]

January–February 1962

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory (HASL) began monitoring liquid whole milk in New York City in 1954 for strontium–90 in order to estimate the dietary contribution from the ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York, and at Mandan, North Dakota. Liquid whole milk monitoring was started at Honolulu, Hawaii in August 1959.

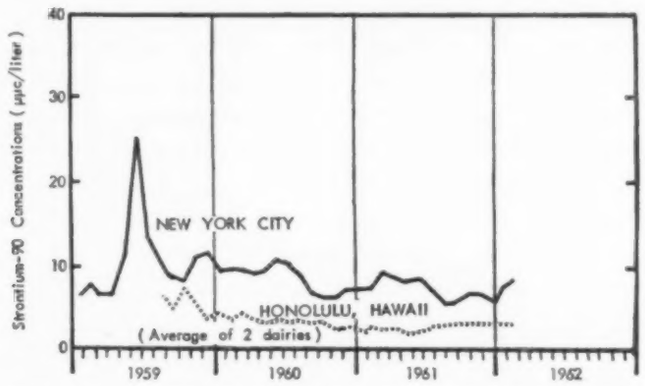


FIGURE 1.—STRONTIUM–90 IN LIQUID MILK SAMPLES

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores, representing 5 large dairies. The Honolulu sample is a monthly composite of pasteurized milk collected weekly, representing two dairies. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants at each city. The Mandan sample is powdered buttermilk used for cattle feed, while the Perry sample is powdered whole milk used for human consumption. The Honolulu data are of interest since the cows are on pasture throughout the year and soil analyses have shown strontium–90 concentrations in soils in

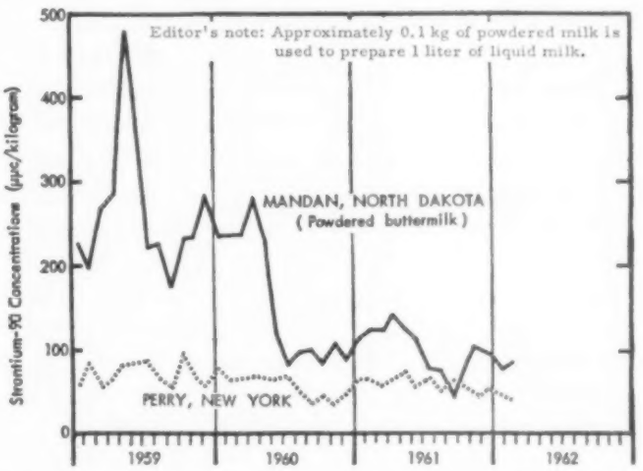


FIGURE 2.—STRONTIUM–90 IN POWDERED MILK SAMPLES

[1] Data from USAEC Report "Fallout Program Quarterly Summary Report," HASL–127, July 1, 1962.

TABLE 1.—RADIOSTRONTIUM AND CALCIUM IN POWDERED MILK JANUARY–FEBRUARY 1962

Sampling station and period	g Ca/kg powder	$\mu\mu c\ Sr^{90}$ / kg powder	$\mu\mu c\ Sr^{90}$ / g Ca	Sr^{89}/Sr^{90}
Perry New York				
1959 Average			8.0	
1960 Average			6.5	
1961 Average			6.1	
1962 January	9.4	49	5.2	3
February	9.3	47	5.0	2
Mandan North Dakota (powdered buttermilk)				
1959 Average			25.7	
1960 Average			15.0	
1961 Average			9.1	
1962 January	11.0	85	7.7	2
February	11.3	88	7.8	2

TABLE 2.—RADIOSTRONTIUM AND CALCIUM IN LIQUID MILK

January–February 1962

Sampling station and period	g Ca/liter	$\mu\mu c\ Sr^{90}$ / liter	$\mu\mu c\ Sr^{90}$ / g Ca	Sr^{89}/Sr^{90}
New York City				
1959 Average			11	
1960 Average			8.0	
1961 Average			6.6	
1962 January	1.3	7.3	5.7	[a]—
February	1.4	8.2	6.1	1
Honolulu Hawaii[b]				
1959 Average			5.0	
1960 Average			3.2	
1961 Average			2.5	
1962 January	1.2	3.0	2.6	10
February	1.0	2.8	2.8	12

[a] — indicates strontium-89 undectable.
[b] average of two dairies.

Hawaii to be comparable with those in the New York area.[2]

Strontium–89 became measurable in September 1961, indicating that fresh fission products from the U.S.S.R. nuclear test series were being deposited. The Sr^{89}/Sr^{90} ratios are presented in tables 1 and 2, as are the calcium and strontium data for January and February 1962. The fluctuations of strontium–90 with time are shown in figures 1 and 2.

[2] USAEC Report No. HASL–90, p. 4, August 18, 1960.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
October 1959	*April 1960*
November 1959	*May 1960*
December 1959	*June 1960*
January–March 1960	*August 1960*
January–March 1960 (Honolulu)	*October 1960*
April–June 1960	*November 1960*
July–August 1960	*March 1961*
August–November 1960	*June 1961*
December 1960–April 1961	*December 1961*
May–July 1961	*March 1962*
August–December 1961	*June 1962*

SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
March 1962

Division of Water Supply and Pollution Control, Public Health Service

The National Water Quality Network, operated in cooperation with State and local agencies and industrial organizations, commenced operations in October 1957. By the end of March 1962, 106 sampling stations were submitting water samples for analysis. These stations are located on major waterways used for public water supply, propagation of fish and wildlife, recreational purposes, and for agricultural, industrial, and other uses. Some of these stations are on interstate, coastal, and international boundary waters, and waters on which activities of the Federal Government may have an impact. Ultimately, a total of approximately 300 stations will be in operation. Radioactivity is not yet being reported for a few of the more recently established stations.

Samples of water are examined for chemical, physical, and biological quality insofar as these relate to pollution. Samples for some determinations are taken weekly, others monthly, and for some, continuous composite samples of 10 to 15 days are obtained.

Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium–90 on the total solids only) in raw surface water samples. The levels of radioactivity associated with dissolved solids provide a rough measure of the levels which may be found in treated water, where such water treatment removes substantially all of the suspended matter. Naturally-occurring radioactive substances in the environment are the source of essentially all of the alpha activity. The contamination of the environment from man-made sources is the major contributor to the beta activity. It should be noted that with the cessation of weapons testing for a period of three years, the beta activity in most raw waters generally had approached a level attributable solely to natural sources. Natural beta activity can be two or three times the natural alpha activity based on the presence of the same nuclides. The resumption of nuclear weapons testing in the atmosphere has resulted in an increase in the radioactivity of raw surface waters.

For the first two years of the Network operations, beta determinations were made on weekly samples. Alpha determinations were reported generally on composites of more than one weekly sample. Since January 1959, a portion of each sample from all stations in the Network

FIGURE 1.—NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, MARCH 1962

has been composited into a 3-month sample for measurement of strontium–90 concentration.

Beginning January 1, 1960, the frequency of beta determinations varied depending on the status of each particular station. For the first operating year of each new station, analyses were being conducted weekly. Weekly analyses were to be continued indefinitely for all stations which may be affected by waste discharges from nuclear installations. Semimonthly determinations (on composites of 2 or 3 weekly samples) were conducted for stations which still showed some beta activity above background. Monthly determinations (on composites of all samples received from a station during the month) were conducted on samples from streams where beta activity was at background levels.

Also in January 1960, the frequency of alpha determinations was changed. For the first operating year of each new station, analyses were done weekly. At some stations on the Colorado and Animas Rivers determinations were done on weekly samples or semimonthly on 2- or 3-week composites. The remainder of the stations were scheduled so that each made one gross alpha determination per month.

Following the resumption of nuclear weapons testing in the atmosphere by the U.S.S.R., the gross beta and alpha determination schedules were altered. Since September 1, 1961, gross beta determinations have been made on all samples collected (compositing weekly samples for monthly or semimonthly gross beta or alpha determinations will cease). Since October 1, 1961, gross alpha determinations have been made on one sample from each station each month, unless there is evidence of alpha activity in excess of background levels. In the latter instance, an alpha determination has been made on a weekly or biweekly basis, depending on what is considered the norm for a particular station.

The data reported in table 1 represent the average of all data reported for the periods indicated. The reported strontium–90 data are the results of determinations on 3-month composite samples for the quarter ending in the month shown.

BIBLIOGRAPHY

(1) *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, Water Years, 1957–58, 1958–59, 1959–60. Public Health Service, Division of Water Supply and Pollution Control, Washington 25, D.C.

(2) "Report on National Water Quality Control Network," submitted by the Chief, Division of Radiological Health, PHS, before the Joint Committee on Atomic Energy Hearings on Fallout from Nuclear Weapons Tests, 1: 167-9 (May 1959).

(3) Setter, L. R., J. E. Regnier, and E. A. Diephaus, "Radioactivity of Surface Waters in the United States," *Journal of the American Water Works Association*, 51: 1377-92 (Nov. 1959).

(4) Straub, C. P., L. R. Setter, A. Goldin, and P. F. Hallbach, "Strontium–90 in Surface Waters," *Journal of the American Water Works Association*, 52: 756-68 (June 1960).

(5) Setter, L. R., and S. L. Baker, "Radioactivity of Surface Waters in the United States," *Radiological Health Data*, 1: 20-31 (October 1960).

(6) Straub, C. P., "Significance of Radioactivity Data," *Journal of the American Water Works Association*, 53: 704-3 (June 1961).

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS

[Average concentrations in μμc/liter[

Station	Quarter ending Dec. 31, 1961	March 1962					
	Strontium-90	Beta activity			Alpha activity		
	Total	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	—	25	19	44	0	0	0
Animas River: Cedar Hill, N. Mex.	—	74	32	106	12	7	19
Apalachicola River: Chattahoochie, Fla.	—	24	16	40	—	—	—
Arkansas River:							
Coolidge, Kansas	—	36	74	110	—	—	—
Ponca City, Okla.	—	17	12	29	0	1	1
Pendleton Ferry, Ark.	—	116	49	165	1	0	1
Big Horn River: Hardin, Mont.	—	53	21	74	8	4	12
Chattahoochie River:							
Columbus, Ga.	—	56	24	80	0	0	0
Atlanta, Ga.	0.3	19	10	29	0	0	0
Chena Slough: Fairbanks, Alaska	—	3	3	6	1	1	2
Clear Water River: East Lewiston, Idaho	0.3	18	12	30	1	0	1
Colorado River:							
Loma, Colo.	—	55	37	92	8	4	12
Page, Ariz.	—	167	43	210	39	10	49
Boulder City, Nev.	—	6	32	38	1	7	8
Parker Dam, Calif.	—	2	29	31	0	5	5
Yuma, Ariz.	—	3	61	64	0	8	8
Columbia River:							
Wenatchee, Wash.	—	5	10	15	0	1	1
Pasco, Wash.	—	53	558	611	0	1	1
Bonneville Dam, Oreg.	—	26	258	284	0	2	2
Clatskanie, Oreg.	—	21	132	153	0	1	1
McNary Dam, Oreg.	—	35	387	422	0	0	0
Connecticut River:							
Northfield, Mass.	—	7	23	30	0	0	0
Wilder, Vt.	—	9	20	29	0	0	0
Delaware River:							
Philadelphia, Pa.	—	22	21	43	0	0	0
Trenton, New Jersey	—	30	19	49	1	0	1
Martins Creek, Pa.	—	16	20	36	0	0	0
Escambia River: Century, Fla.	—	37	18	55	1	0	1
Great Lakes:							
Buffalo, N. Y.	0.8	13	22	35	0	0	0
Detroit, Mich.	—	12	16	28	0	0	0
Port Huron, Mich.	—	4	8	12	0	0	0
Milwaukee, Wis.	—	2	7	9	1	1	2
Sault Ste. Marie, Mich.	—	1	5	6	0	0	0
Gary, Ind.	0.1	12	12	24	0	0	0
Duluth, Minn.	—	10	2	12	0	0	0
Hudson River: Poughkeepsie, N. Y.	—	32	41	73	—	—	—
Illinois River: Peoria, Ill.	—	64	58	122	1	0	1
Kanawha River: Winfield Dam, W. Va.	—	29	10	39	0	0	0
Klamath River: Copco, Oreg.	—	30	36	66	0	0	0
Little Miami River: Cincinnati, Ohio	0.6	—	—	—	—	—	—
Mississippi River:							
St. Paul, Minn.	—	3	14	17	0	1	1
Dubuque, Iowa	—	27	27	54	0	1	1
Burlington, Iowa	—	84	24	108	0	1	1
E. St. Louis, Ill.	—	104	60	164	—	—	—
Cape Girardeau, Mo.	—	137	45	182	0	2	2
Delta, La.	—	67	33	100	—	—	—
New Orleans, La.	—	80	27	107	3	1	4
Vicksburg, Miss.	—	76	31	107	4	<1	4
Missouri River:							
Williston, N. Dak.	—	23	17	40	2	3	5
Bismarck, N. Dak.	—	16	18	34	0	4	4
Yankton, S. Dak.	—	23	30	53	0	7	7
Omaha, Nebr.	—	41	70	111	—	—	—
St. Joseph, Mo.	—	70	43	113	8	2	10
Kansas City, Kans.	—	151	47	198	—	—	—
St. Louis, Mo.	—	100	31	131	14	2	16
Monongahela River: Pittsburgh, Pa.	—	26	14	40	2	<1	2
North Platte River: Henry, Nebr.	—	7	49	56	1	30	31

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS—Continued

Station	Quarter ending Dec. 31, 1961	March 1962					
	Strontium-90	Beta activity			Alpha activity		
	Total	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Ohio River:							
East Liverpool, Ohio	—	23	15	38	1	0	1
Huntington, W. Va	—	40	15	55	1	0	1
Cincinnati, Ohio	—	52	18	70	0	0	0
Louisville, Ky	—	62	17	79	4	<1	4
Evansville, Ind	—	84	22	106	3	0	3
Cairo, Ill	—	80	34	114	—	—	—
Ouachita River: Bastrop, La	—	45	52	97	1	0	1
Platte River: Plattsmouth, Nebr	—	22	44	66	0	6	6
Potomac River:							
Williamsport, Md	—	8	10	18	0	1	1
Great Falls, Md	—	4	10	14	—	—	—
Rainy River:							
Baudette, Minn	—	14	10	24	1	0	1
International Fls, Minn	—	1	8	9	0	0	0
Red River, South:							
Alexandria, La	—	101	35	136	—	—	—
Denison, Tex	—	15	31	46	0	1	1
Rio Grande River:							
Alamosa, Colo	—	11	22	33	<1	1	1
El Paso, Tex	—	44	14	58	3	4	7
Laredo, Tex	—	14	16	30	1	3	4
Brownsville, Tex	—	13	17	30	0	0	0
Roanoke River: John H. Kerr Resr. & Dam, Va	—	33	19	52	0	0	0
Sabine River: Ruliff, Tex	—	29	44	73	0	0	0
San Juan River: Shiprock, N. Mex	—	53	30	83	7	11	18
St. Lawrence River: Massena, N. Y	—	10	18	28	0	0	0
Schuylkill River: Philadelphia, Penn	—	19	30	49	1	0	1
Savannah River:							
North Augusta, S. C	—	24	13	37	—	—	—
Port Wentworth, Ga	—	36	54	90	—	—	—
Shenandoah River: Berryvilla, Va	0.2	32	11	43	1	0	1
Ship Creek: Anchorage, Alaska	—	2	6	8	0	0	0
Snake River:							
Wawawi, Wash	—	16	16	32	3	1	4
Payette, Idaho	—	15	27	42	1	3	4
South Platte River: Julesburg, Colo	—	37	71	108	2	33	35
Susquehanna River:							
Sayre, Pa	—	26	33	59	0	0	0
Conowingo, Md	—	41	18	59	—	—	—
Tennessee River:							
Lenoir City, Tenn	—	26	22	48	1	0	1
Chattanooga, Tenn	0.5	14	24	38	—	—	—
Bridgeport, Ala	—	10	19	29	0	0	0
Pickwick Landing, Tenn	—	28	41	69	<1	0	<1
Tombigbee River: Columbus, Miss	0.2	27	19	46	0	0	0
Truckee River: Farad, Calif	—	21	32	53	0	0	0
Verdigris River: Nowata, Okla	—	147	61	208	3	0	3
Yakima River: Richland, Wash	—	5	8	13	0	1	1
Yellowstone River: Sidney, Mont	—	29	32	61	18	5	23

Radiostrontium in Tap Water[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory (HASL) has been assaying monthly composites of daily samples of tap water for strontium–90 at New York City since August 1954 and at Richmond, California since April 1958. Strontium–89 has been determined since September 1961.

The strontium–90 concentrations and strontium–89/strontium–90 ratios from January through April 1962 are presented in table 1, while the strontium–90 concentrations through April 1962 are plotted in figure 1. Data prior to 1958 appear in an earlier HASL report.[2]

[1] U.S. Atomic Energy Commission, *Fallout Program Quarterly Summary Report, HASL–127*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1, 1962), price $3.00.

[2] U.S. Atomic Energy Commission, *Environmental Contamination from Weapon Tests, HASL–42*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (October 1962), price $3.50.

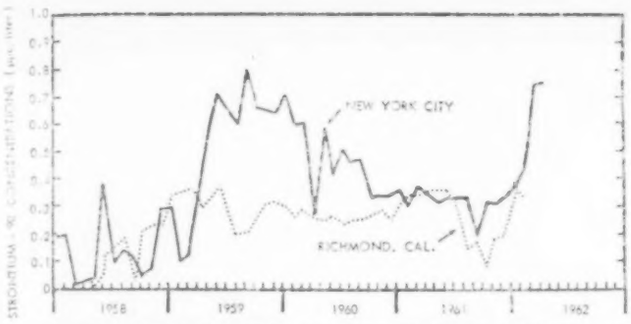


FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN TAP WATER

Comments

The results presented in figure 1 show that prior to 1961 the strontium–90 concentrations in tap water from Richmond were lower than those in tap water from New York City, which is the usual east-west relationship. The levels in both cities were about the same for the first half of 1961, which may be due to the similarities between fallout rates in these areas.[3] After January 1962, the strontium-90 concentrations increased sharply in both cities to 1959 levels, with the usual east–west relationship again being demonstrated. The strontium–89/strontium–90 ratios indicate injection of fresh fission products, including strontium–89 at Richmond. It is evident from these data that debris from the U.S.S.R. testing series is entering the water supply systems and is mixing with the older debris already present.

[3] U.S. Atomic Energy Commission, *Fallout Program Quarterly Summary Report, HASL–122*, Office of Technical Services, Department of Commerce, Washington 25, D.C. (April 1, 1962), price $3.00.

TABLE 1.—RADIOSTRONTIUM IN TAP WATER

Month	New York City		Richmond, California	
	Sr^{90} ($\mu\mu$c/liter)	Sr^{89}/Sr^{90}	Sr^{90} ($\mu\mu$c/liter)	Sr^{89}/Sr^{90}
1959 Average	0.40		0.29	
1960 Average	0.47		0.26	
1961 Average	0.32		0.25	
1962 January	0.37	8.3	0.35	14
February	0.42	5.9	0.31	11
March	0.73	3.1		
April	0.74	7.7		

Previous coverage in *Radiological Health Data:*

Period	*Issue*
September 1959	*April 1960*
December 1959	*July 1960*
December 1959 and first quarter 1960	*August 1960*
Second quarter 1960	*December 1960*
Third quarter 1960	*April 1961*
Fourth quarter 1960	*September 1961*
First quarter 1961	*December 1691*
Second quarter 1961	*March 1962*
Third and fourth quarters 1961	*June 1962*

SECTION V.—OTHER DATA

Mid-May Iodine–131 Fallout in the Midwest

U.S. Weather Bureau, Department of Commerce, and
Division of Radiological Health,
Public Health Service

Iodine–131 attributed to the Christmas Island tests was first observed in pasteurized milk in some of the midwestern States during the second and third weeks of May 1962. Since that time, additional data and information have been secured from the U.S. Weather Bureau and the Radiation Surveillance Network (RSN) which show some correlation with the occurrence of iodine–131 in milk.

Fission Product Activity in Air

Fission product activity of airborne particulates is monitored continuously at about 70 stations by the RSN. To adequately describe fission product activity, both gross beta concentration and age of fission products are necessary. (Refer to page 311 for the method of determination of concentration and age of fission products.) The upper two maps on each page of figure 1 give a geographical day-by-day progression (May 8–15) of the fission product gross beta concentrations of particulates in surface air and the extrapolated age of fission products in days after formation.

The age shown by the age contours is an apparent or average age. For example, an apparent age of 60 days only 15 days after the first test of the series indicates a mixture of fresh products with some of the older activity from the 1961 U.S.S.R. tests.

Precipitation

Precipitation data are presented in the lower maps of figure 1. The numbers inside the rectangles represent the extrapolated age of fission products in days and the total beta activity deposited by rainfall during a 24 hour period as determined by RSN. The shaded areas represent depth of precipitation in millimeters as measured by the Weather Bureau during a 24–hour period ending 1:00 a.m., EST, on the same date. The fronts and the high and low pressure centers are shown for 1:00 a.m.[1]

Although the blank areas on the precipitation maps indicate no precipitation, it is possible that some of these areas may have received small local showers that fell between the coarse network of Weather Bureau stations. Several such showers were detected by radar and are so indicated in table 1.

Iodine–131 in Milk

Iodine–131 concentrations in composited pasteurized milk are monitored in 61 cities

[1] U.S. Department of Commerce, Weather Bureau, *Daily Weather Map* (May 8–15, 1962).

TABLE 1.—U. S. WEATHER BUREAU RAINFALL DATA

[Depth of rainfall in mm]

Station	1962												
	May 4	May 5	May 6	May 7	May 8	May 9	May 10	May 11	May 12	May 13	May 14	May 15	May 16
Little Rock, Ark.	0	0	0	[a]T	0	0	0	0	0	0	0	0	0
Denver, Colo.	0	0	[b]0	T	0	0	0	0	0	0	0	0	0
Chicago, Ill.	0	0	4.0	0	19	0	4.2	2.5	0	17	0	0	0
Des Moines, Iowa	0	0	6.0	0	40	0	T	0	0	0	T	0	0
Wichita, Kans.	T	0	0	0	0	0	[b]0	[b]T	0	0	0	0	0
Minneapolis, Minn.	T	0.5	0	0	3.5	0	T	T	60	24	1.0	0	10
Kansas City, Mo.	0	0	0	0	0	4.8	0	T	0	0	0	0	0
St. Louis, Mo.	0.2	0	0	0.5	2.0	0	0	19	0	0	0	0	0
Syracuse, N. Y.	0.2	0	0	6.5	0	1.5	0	0	0	0	3.5	0	0
Cincinnati, Ohio	0	0	0	T	0.2	3.3	T	12	0	0	0	0	0
Chattanooga, Tenn.	0	0	0	0	0	0	T	0	0	0	0	0	0
Charleston, W. Va.	0	0	0	0	3.8	0	0	0	0	0	1.0	0	0

[a] T indicates trace.
[b] Although no measureable rain was reported, radar echoes indicated precipitation in the vicinity.

TABLE 2.—IODINE-CONCENTRATIONS IN PASTEURIZED MILK, AT SELECTED STATIONS[1]

[Concentrations in μμc/liter]

Milk sampling station / Date May 1962	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Little Rock, Ark.							30									<10	40				
Denver, Colo.			<10							45							<10				
Des Moines, Iowa			<10							300							60				75
Wichita, Kans.																					
Louisville, Ky.	<10					670		660					215		165					250	
Minneapolis, Minn.				<10				20			290				30			170			
Kansas City, Mo.			45								605							150			
St. Louis, Mo.		15							80					50			<10				75
Syracuse, N. Y.				<10																	
Cincinnati, Ohio			<10							50							20				
Chattanooga, Tenn.			<10					30							<10						
Charleston, W. Va.				<10							40						50				

[1] Data from Pasteurized Milk Monitoring Network, compiled by the Radiation Surveillance Center.

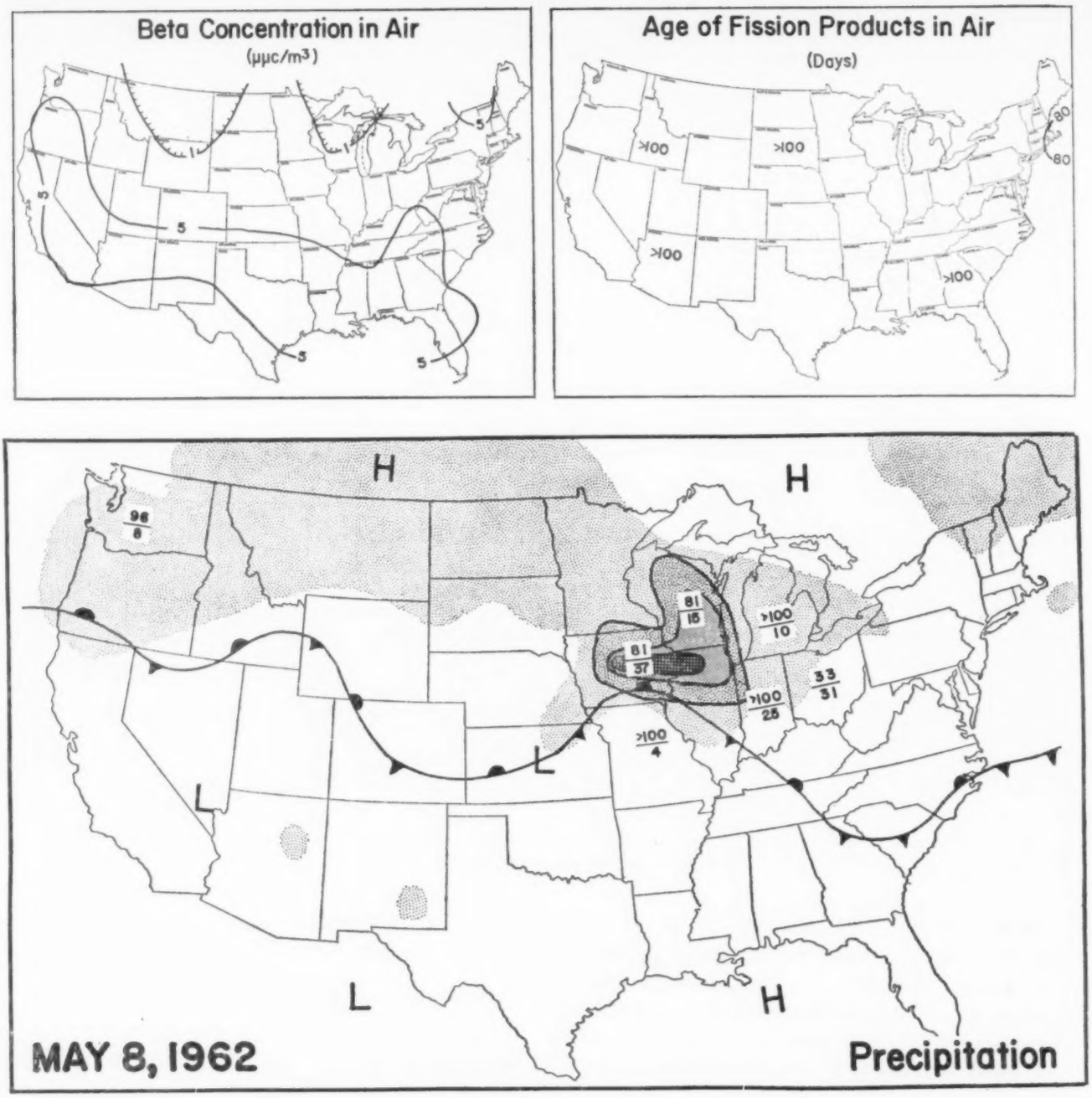
by the Public Health Service Milk monitoring Network (see page 336). The milk collection areas (milksheds) for 11 of the midwestern sampling points are shown in figure 2, and the iodine–131 concentrations in milk from the same locations during the second and third weeks of May are presented in table 2.

More detailed milk sampling data within the midwest region for the May 8–15 period were obtained from the St. Louis County Health Department's Market Milk Study. These data are of particular interest to show possible relations to the meteorological and other data for the St. Louis milk collection area, since the milk samples are composited identically to the PHS Pasteurized Milk Monitoring Program sample for St. Louis and are collected daily. Table 3 and figure 3 present the daily concentrations of iodine–131 in St. Louis for May 8–28 and an estimated average precipitation in the St. Louis milk collection area based on the *Daily Weather Maps.*

Interpretation

Laboratory examination of gross beta concentrations in air* (see concentration contour maps in figure 1) shows no evidence of any unusual event which could be associated with the appearance of iodine in milk, in the central portion of the United States during the second week of May. However, age of fission product analysis* of the RSN air filter samples permits the development of fission product age contour maps (figure 1) which point out a more revealing picture. Here, the intrusion of fresh fission products as shown on these maps coincides with the area where relatively high levels of iodine–

* A minimum of 10 days after date of air filter removal is required for the gross beta concentration and age of fission product determinations.



LEGEND

Fission Product Activity in Precipitation 24 Hour Period Ending 8:00 a.m. Local Time of the Date Indicated. (Same Period Applies to Air Maps Above)

>100 / 35

Top Number Indicates Age of Fission Products At Time of Collection (Example: Greater Than 100 Days)

Bottom Number Indicates Total Deposition of Beta Activity (Example: 35mμc/m²)

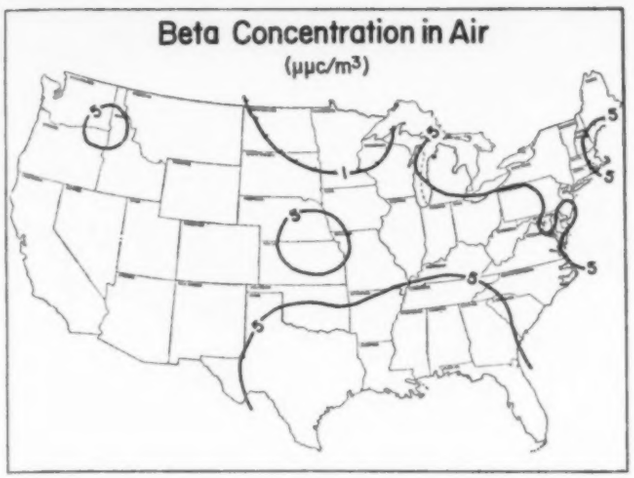
Total Precipitation During the 24 Hour Period Ending 1:00 a.m. EST of the Date Indicated

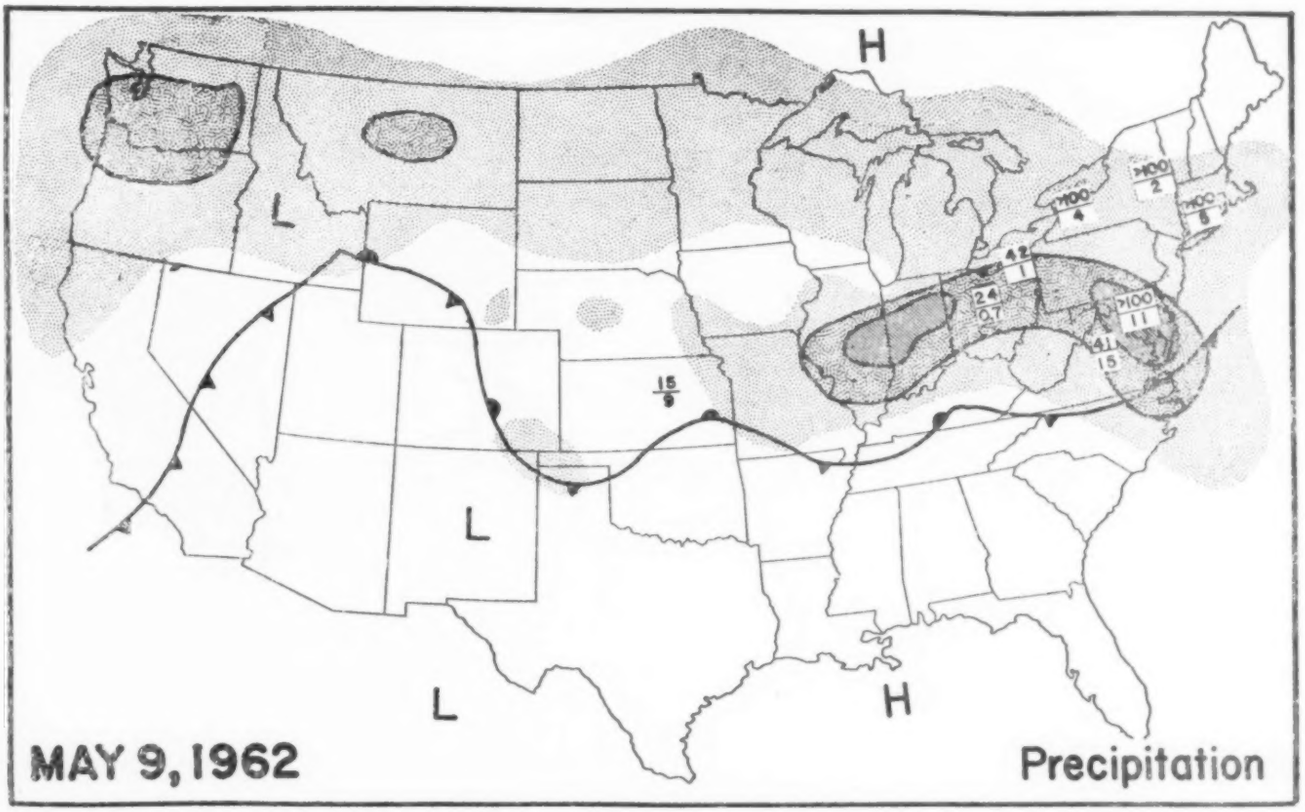
- Trace–5mm
- 5–10mm
- 10–25mm
- >25mm

Weather Symbols Showing Conditions At 1:00 a.m. EST

- Cold Front
- Warm Front
- Stationary Front
- Occluded Front
- H — High Pressure Area
- L — Low Pressure Area

FIGURE 1.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR TO TOTAL PRECIPITATION





LEGEND

Fission Product Activity in Precipitation 24 Hour Period Ending 8:00 a.m. Local Time of the Date Indicated. (Same Period Applies to Air Maps Above)

>100 / 35

Top Number Indicates Age of Fission Products At Time of Collection (Example: Greater Than 100 Days)

Bottom Number Indicates Total Deposition of Beta Activity (Example: 35mμc/m²)

Total Precipitation During the 24 Hour Period Ending 1:00 a.m. EST of the Date Indicated

Trace-5mm

10-25mm

5-10mm

>25mm

Weather Symbols Showing Conditions At 1:00 a.m. EST

Cold Front

Warm Front

Stationary Front

Occluded Front

H High Pressure Area

L Low Pressure Area

FIGURE 1.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR TO TOTAL PRECIPITATION—Continued

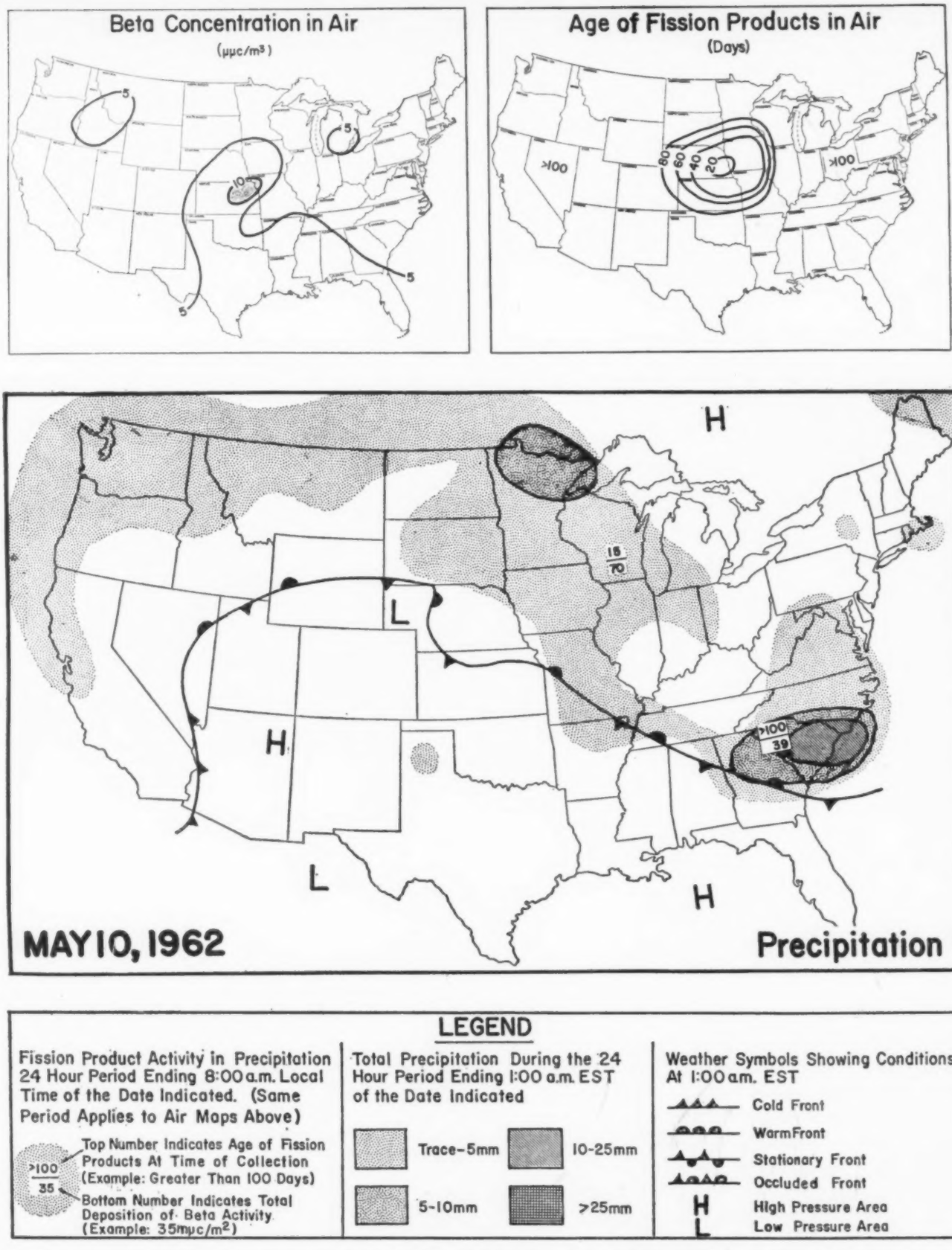


FIGURE 1.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR TO TOTAL PRECIPITATION—Continued

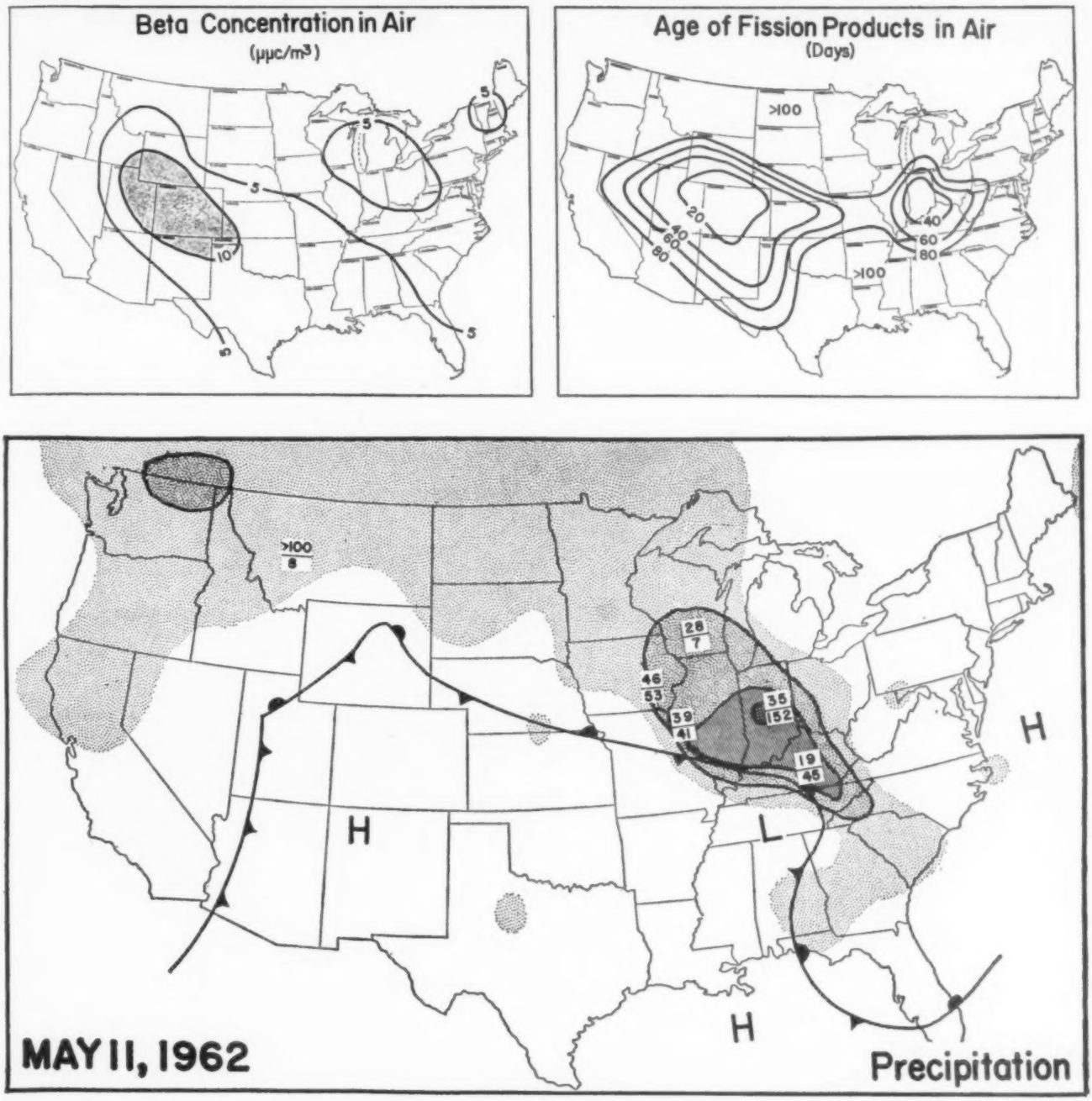


FIGURE 1.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR TO TOTAL PRECIPITATION—Continued

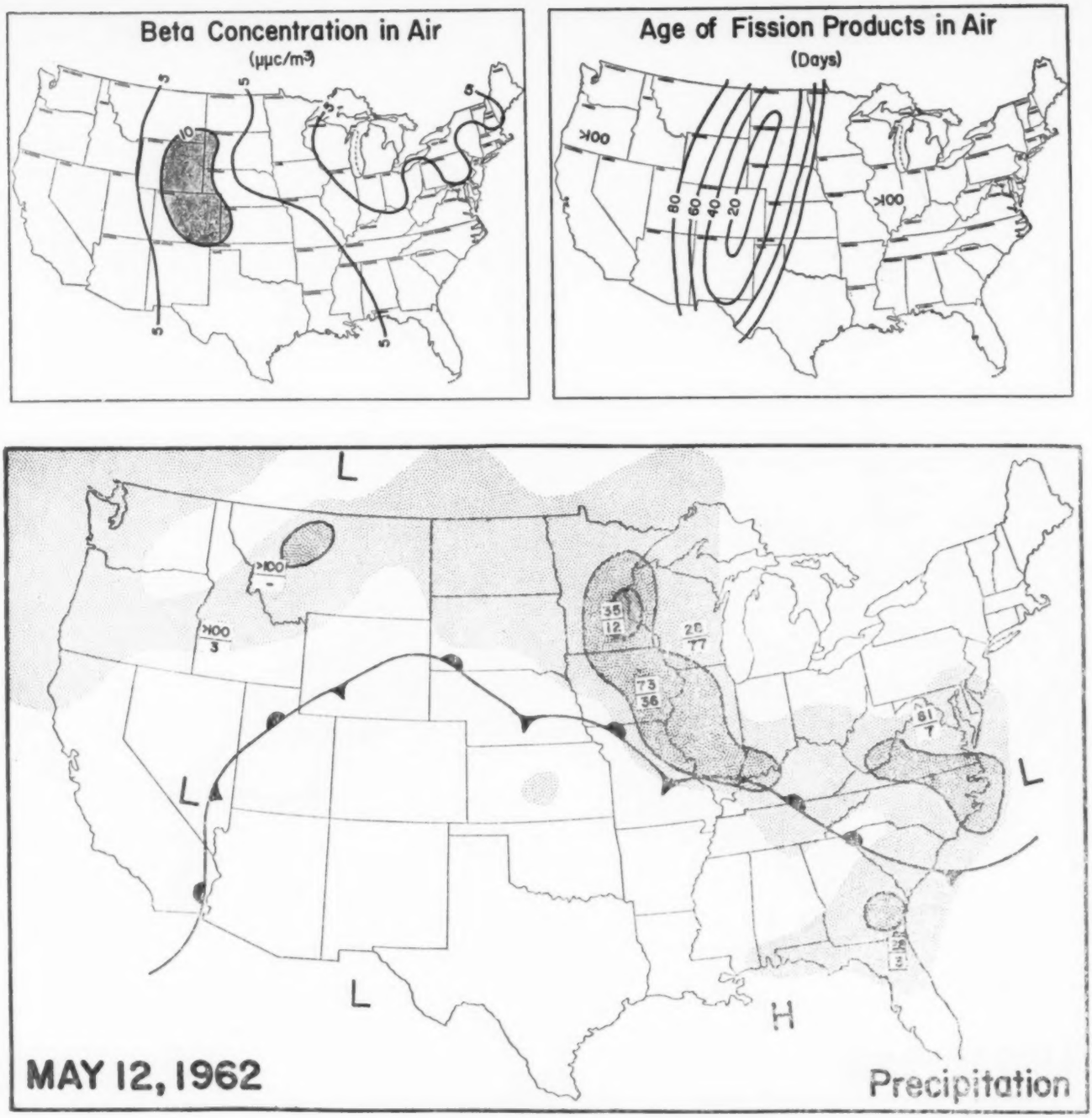

Beta Concentration in Air
(μμc/m³)
Age of Fission Products in Air
(Days)
>100
80
60
40
20
MAY 12, 1962
Precipitation
LEGEND
Fission Product Activity in Precipitation 24 Hour Period Ending 8:00 a.m. Local Time of the Date Indicated. (Same Period Applies to Air Maps Above)
Top Number Indicates Age of Fission Products At Time of Collection (Example: Greater Than 100 Days)
Bottom Number Indicates Total Deposition of Beta Activity (Example: 35mμc/m²)
Total Precipitation During the 24 Hour Period Ending 1:00 a.m. EST of the Date Indicated
Trace-5mm
10-25mm
5-10mm
>25mm
Weather Symbols Showing Conditions At 1:00 a.m. EST
Cold Front
Warm Front
Stationary Front
Occluded Front
High Pressure Area
Low Pressure Area

FIGURE 1.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR TO TOTAL PRECIPITATION—Continued

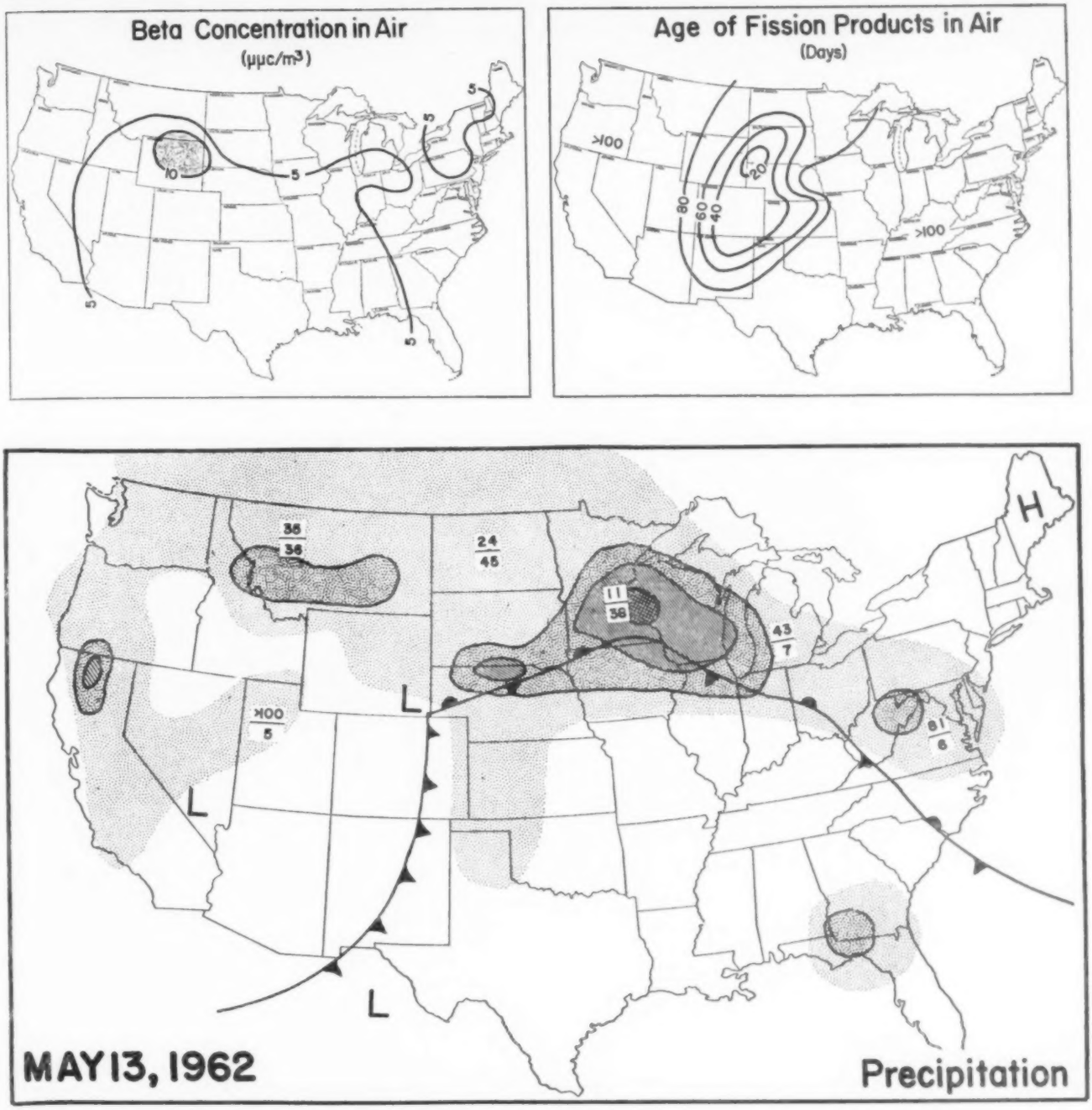


FIGURE 1.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR TO TOTAL PRECIPITATION—Continued

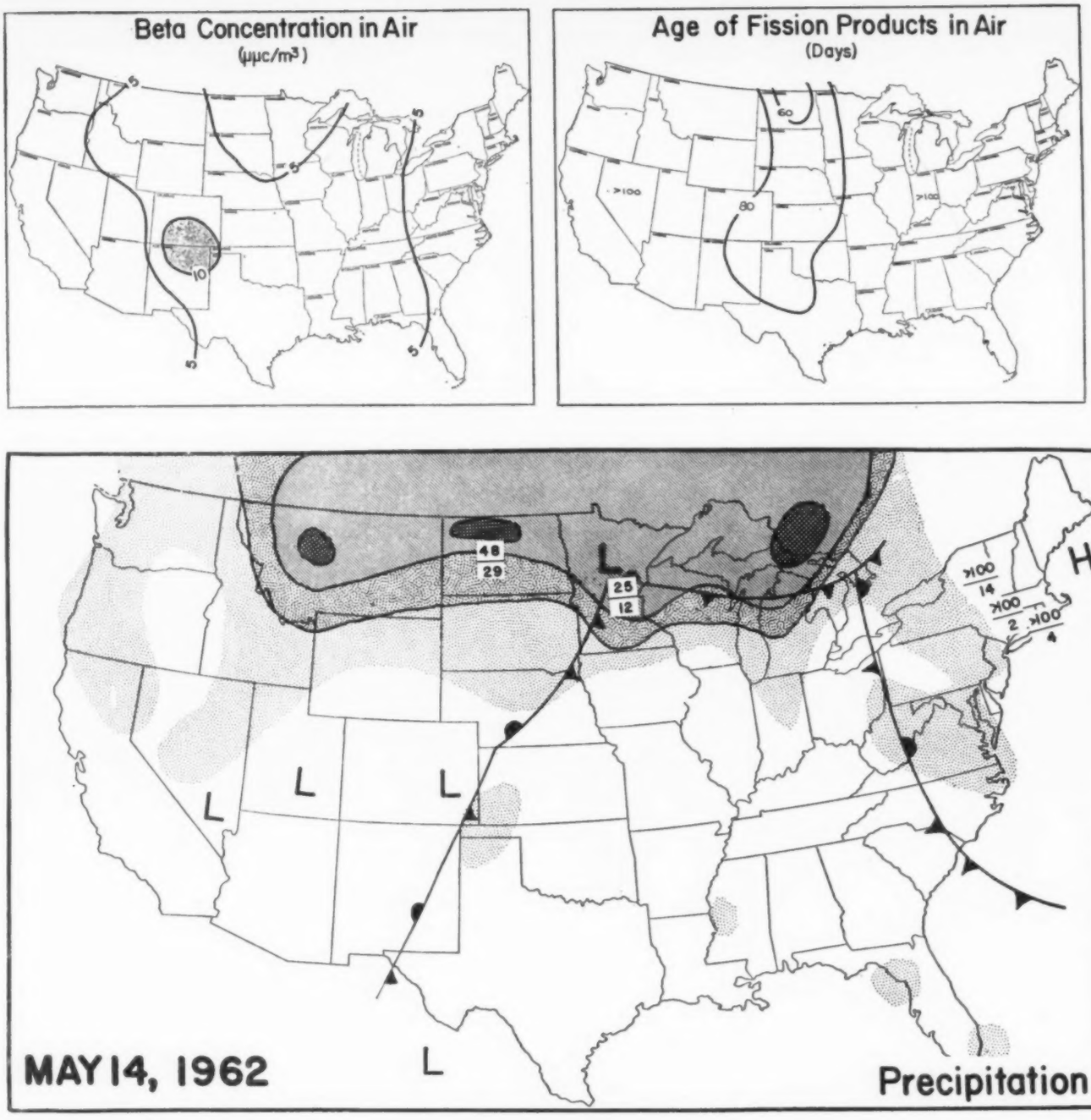


FIGURE 1.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR TO TOTAL PRECIPITATION—Continued

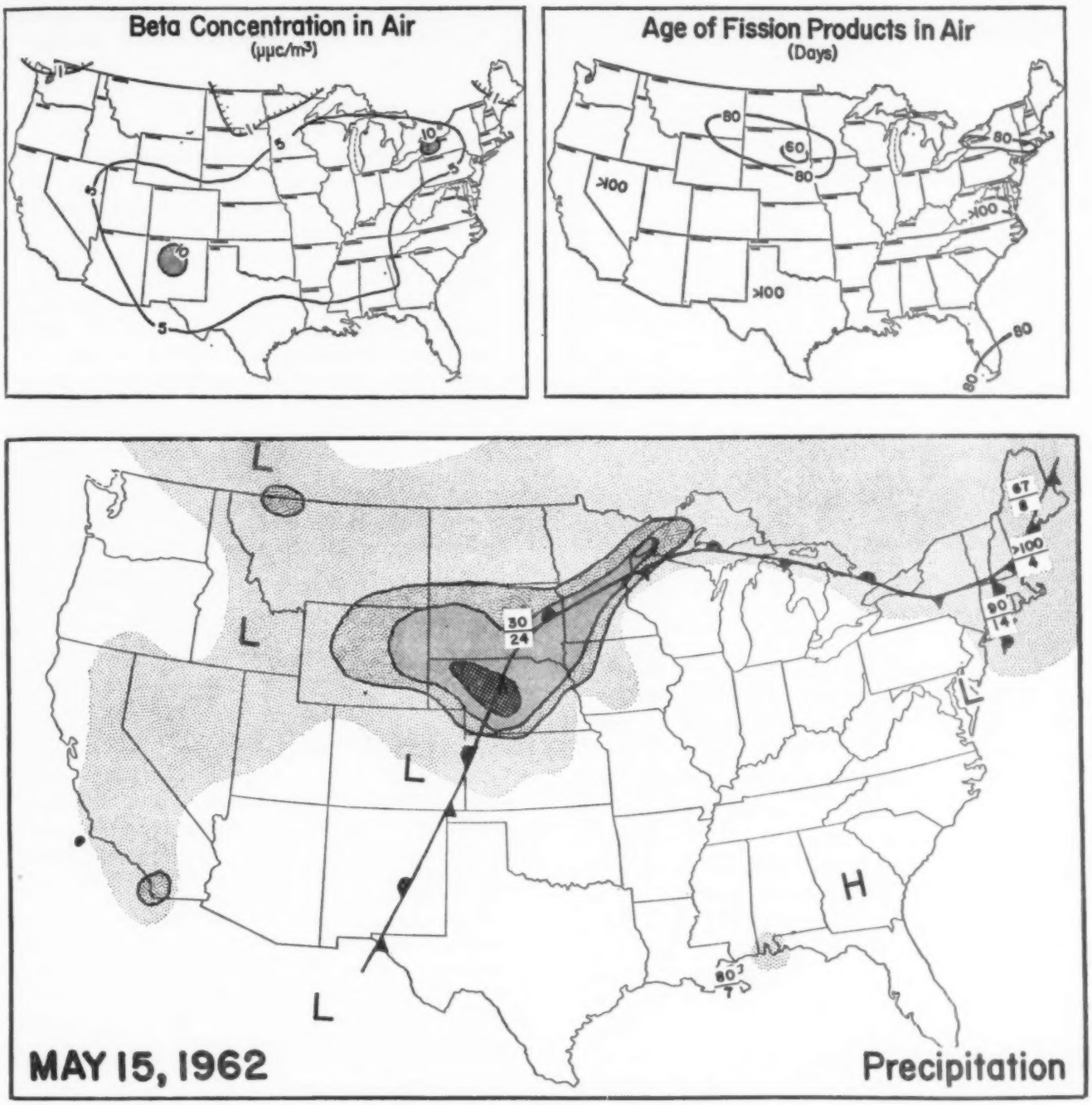

Beta Concentration in Air
(μμc/m³)
Age of Fission Products in Air
(Days)
MAY 15, 1962
Precipitation
LEGEND
Fission Product Activity in Precipitation 24 Hour Period Ending 8:00 a.m. Local Time of the Date Indicated. (Same Period Applies to Air Maps Above)
>100
35
Top Number Indicates Age of Fission Products At Time of Collection (Example: Greater Than 100 Days)
Bottom Number Indicates Total Deposition of Beta Activity (Example: 35mμc/m²)
Total Precipitation During the 24 Hour Period Ending 1:00 a.m. EST of the Date Indicated
Trace-5mm
10-25mm
5-10mm
>25mm
Weather Symbols Showing Conditions At 1:00 a.m. EST
Cold Front
Warm Front
Stationary Front
Occluded Front
H High Pressure Area
L Low Pressure Area

FIGURE 1.—COMPARISON OF DAILY FISSION PRODUCT CONCENTRATION AND AGE IN AIR TO TOTAL PRECIPITATION—Continued

TABLE 3.—IODINE-131 IN MARKET MILK IN ST. LOUIS AND PRECIPITATION IN THE ST. LOUIS COLLECTION AREA[a]

1962	Estimated precipitation		I^{131} in milk ($\mu\mu$c/liter)
	Percent of area with rain	Average mm of ppt.	
May 8	30%	7	[b]ND
9	80%	5	9
10	80%	2	ND
11	70%	10	ND
12	70%	5	6
13	20%	2	[c]—
14	0%	0	32
15	5%	Trace	49
16	10%	Trace	74
17	0%	0	66
18	30%	1	76
19	0%	0	58
20	20%	15	—
21	20%	Trace	38
22	40%	Trace	46
23	40%	3	37
24	10%	Trace	26
25	30%	Trace	17
26	100%	5	45
27	80%	5	—
28	100%	2	30

[a] Milk sampling by the St. Louis County Health Department; precipitation estimated from Daily Weather Maps U.S. Weather Bureau.
[b] ND indicates non-detectable.
[c] — indicates no sample.

131 were observed in milk. Because of its short half life (8 days), iodine–131 from fallout is associated only with relatively fresh fission products.

Because fresh fission product activity in precipitation can usually be demonstrated in the chain of events for transmitting iodine–131 to milk, careful attention was directed to the precipitation and other meteorological data in the vicinities of various cities where radioiodine was found in milk. It can be observed that some of the areas where iodine–131 was detected had heavy rains, but others, notably Wichita, Kansas, apparently had little or no rain at all, based on the *Daily Weather Maps*.

One possible explanation for this apparent anomaly is suggested in the following comments submitted by Dr. Lester Machta, Chief, Meteorological Research Projects Branch, U.S. Weather Bureau.

> ". . . It is the nature of thundershowers that they are localized and the reports of rainfall at the Weather Bureau Airport rain gauge may not reflect the correct amount or even the presence of rainfall at the pasture fields. . . . Radar, however, does see all rainshowers within its range and in many instances it is clear from the radar reports that there must have been rain between the coarse network of reporting raingauges. . . . The Weather Bureau is currently reporting, on an experimental basis, the tops of radar echoes. Inspection of these cloud top reports indicates that during the period of 10–14 May, some of the thunderclouds rose to heights of 50,000 feet or more. At the same time, the officially reported height of the tropopause was about 40,000 ± 2,000 feet. Thus, it may be concluded that even if radioactive debris were entirely confined to the stratosphere (which at present is not confirmed), it is entirely possible that precipitation could have brought down material from within the stratosphere.
>
> "Debris was present in the lower stratosphere, between 50,000 and 60,000 feet as early as 8 May (and possibly earlier) over the U.S. between 31 and 42°N from information provided by the Stardust program of the Defense Atomic Support Agency. Preliminary dating of the debris found in these stratospheric samples suggested early May (possibly the 4th) as the time of origin. Thus, it is known that there was debris in the lower stratosphere at the probable time of the penetration of this level by the thunderclouds."

Dr. Machta also discussed the possible origin of the radioactive debris as follows:

> "The origin of the debris cannot be identified with absolute confidence. Normally, if a meteorological trajectory coincides with the arrival of debris from an announced detonation, this is accepted as proof of origin in the absence of radiochemical dating. This is not possible because the only announced nuclear tests since April 25, 1962 took place at Christmas Island and there are insufficient weather data to be able to compute a trajectory of the air masses carrying the nuclear debris from Christmas Island. However, during the period from 6–7 May through 15 May there was a flow of air in the upper troposphere and lower stratosphere in the western part of the U.S. from the west-southest or the southwest. Any debris from Chrismas Island tests which may, by some unknown trajectory, have been carried to about latitude 25°N off the Mexican west coast might reasonably be carried to the region covered by the stations listed in table 1."

More detailed study of the succession of meteorological and other events in the midwest for mid-May was made possible by examining the profile of the St. Louis daily composite milk samples (figure 3). This profile shows iodine–131 not detectable on May 11, barely detectable on May 12, and reaching a peak on May 16. From the precipitation maps it is evident that some rain fell in the milkshed during May 9 and 10 with the possibility of deposition of fresh fission products at that time. However, the date when most of the young activity was introduced

was probably May 11 when heavy rains with considerable deposition of young activity were reported in the area. (Note: these dates correspond to the map dates.) In this example iodine–131 was detected in market milk 1 or 2 days after the most probable date of its injection by rain. At least 5 days then elapsed before the radioiodine reached a peak in pasteurized milk.

Examining the iodine values in St. Louis milk further, the question is raised as to the meaning of the second and third peaks on May 18 and 22, since they may represent artifacts of experimental deviations, or further injections of fresh activity into the milk collection area. Although not shown in figure 1, weather maps and RSN data indicate trace to light rains with possible fresh fission products in the St. Louis milkshed on May 16 and 18. Conceivably they could have introduced sufficient activity to produce the later peaks, but the evidence is not conclusive since the first injection of activity was associated with a very heavy rainfall.

The Wichita radioiodine in milk profile in figure 1 shows a peak on May 13 one order of magnitude higher than the St. Louis peak. Since the May 15 milk sample showed nearly the same level of radioiodine as on the 13th, it is possible that the peak occurred between these dates. Applying a 5-day minimum lapse period derived from the St. Louis data places the estimated date of injection of radioiodine in the Wichita milk collection area as May 8 or 9. Although little or no rain was evident in the milkshed during that period, the young activity appearing in air on May 9 gives evidence of a substantial injection at that time. The mode of injection is open to question. If there were

FIGURE 2.—SELECTED MILKSHED AREAS

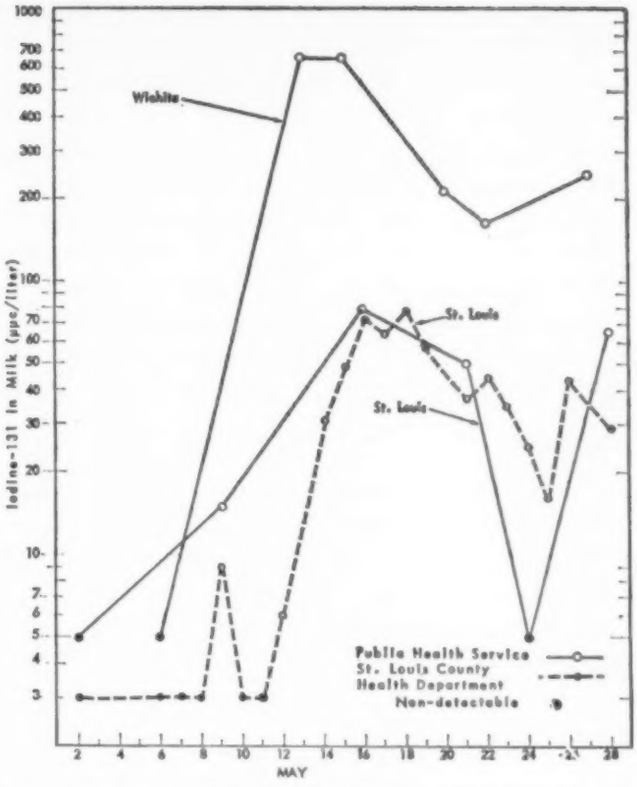


FIGURE 3.—SELECTED TIME PROFILES OF IODINE–131 IN MILK

thunderstorms on May 8 or 9 similar to the ones described by Dr. Machta on May 10-14, such an injection from the stratosphere would be possible.

Although heavy rains were probably involved in the St. Louis example (see figure 3) in the Wichita milkshed, trace or light scattered rains, or even some other mechanism for radioiodine deposition on pasture, could be implicated. This implication of the effects of spotty or trace rainfall supports the hypothesis that the second and third peaks in the St. Louis daily profile (figure 3) are real.

After the peak in a profile, and with no further injections, the iodine–131 concentrations in milk drop sharply. From the profile slope an effective half-life may be determined. Such a value may be useful in extrapolating iodine–131 in milk profiles back to a probable date of peak when no sample was collected on that day.

The profiles for several cities in table 2 (Kansas City, Des Moines, Omaha, and Wichita) having relatively high iodine–131 values show effective half-lives of 3 to 3.6 days. The St. Louis profile from PHS data shows a half-life of 7.2 days. However, if daily values are

considered, using the St. Louis Health Department data, and the second and third peaks are presumed real, the downslopes average approximately 3.1 days effective half-life. The agreement of this value with those profiles of higher concentration lends further weight to the argument that the small peaks on the St. Louis profile are real. It also suggests that small injections of this type tend to flatten the slopes of lower activity range profiles such as St. Louis but have little effect on the slopes of higher activity range profiles such as Wichita.

Summary

From the data presented, it is apparent that, although gross beta concentrations in air do not always give indications of fresh fission product intrusions, the development of isocontour maps showing the age of fission products can demonstrate a meteorological event associated with an increase in radioiodine in milk. The St. Louis time-concentration profile of iodine–131 in market milk samples shows that radioiodine was detected 1 or 2 days after injection and reached a peak value about 5 days after injection of fresh fission products into the milk collection area. After the peak, an effective half life of 3.0 to 3.5 days was observed, excluding the effect of subsequent fresh fallout injections.

Also it appears that deposition of fresh activity onto the grass may be affected by heavy rains, by relatively light rains, or by some other mechanism. A final comment by Dr. Machta may suggest some explanations.

> ". . . If the rainfall at the station is taken literally as the amount which fell on the milkshed (and this has already been questioned), the highest reading at Wichita, for example, corresponded with only a trace of rain on 10–11 May. Is this amount of water, less than 0.01 inches, enough to bring down significant amounts of I^{131}? Is it likely that much of the I^{131} deposited on plants early in a rainshower is washed off by the later rain? Does a trace of rain which may have resulted from the evaporation of a much larger amount of water during descent contain just as much fission products, but these do not leave the water during its evaporation?"

External Gamma Activity

Division of Radiological Health, Public Health Service

Daily measurements of external gamma radiation are made at stations of the Radiation Surveillance Network to assure detection of any substantial deviations from normal background levels. Portable Geiger-Mueller survey instruments are used to obtain measurements at three feet above the ground surface. June 1962 data reported in table 1 are characteristic of individual station observations which in recent years have defined the range of normal background values.

TABLE 1.—EXTERNAL GAMMA ACTIVITY, JUNE 1962

Station location		Average (mr/hr)	Station location		Average (mr/hr)
City	State		City	State	
Adak	Alaska	0.01	Lansing	Mich.	0.02
Anchorage	Alaska	0.01	Minneapolis	Minn.	0.01
Attu	Alaska	0.01	Jackson	Miss.	0.01
Fairbanks	Alaska	0.01	Pascagoula	Miss.	[a]—
Juneau	Alaska	0.01	Jefferson City	Mo.	0.01
Kodiak	Alaska	0.01	Helena	Mont.	0.03
Nome	Alaska	0.01	Lincoln	Nebr.	0.01
Point Barrow	Alaska	0.01	Las Vegas	Nev.	0.01
St. Paul Island	Alaska	0.01	Trenton	N. J.	0.02
Phoenix	Ariz.	0.01	Concord	N. H.	—
Little Rock	Ark.	0.01	Santa Fe	N. Mex.	0.04
Berkeley	Calif.	0.01	Albany	N. Y.	0.02
Los Angeles	Calif.	0.02	Buffalo	N. Y.	0.01
Denver	Colo.	0.02	New York	N. Y.	—
Hartford	Conn.	0.01	Gastonia	N. C.	0.02
Dover	Del.	0.01	Bismarck	N. D.	0.01
Washington	D. C.	0.02	Columbus	Ohio	0.01
Jacksonville	Fla.	0.02	Painesville	Ohio	0.01
Miami	Fla.	0.01	Oklahoma City	Okla.	0.02
Atlanta	Ga.	0.03	Ponca City	Okla.	0.02
Agana	Guam	0.01	Portland	Ore.	0.02
Honolulu	Hawaii	0.01	Harrisburg	Pa.	0.01
Boise	Idaho	0.02	San Juan	P. R.	—
Springfield	Ill.	0.01	Providence	R. I.	0.02
Indianapolis	Ind.	0.02	Columbia	S. C.	0.02
Iowa City	Iowa	0.01	Pierre	S. D.	0.02
Topeka	Kans.	0.02	Nashville	Tenn.	0.01
Frankfort	Ky.	0.01	Austin	Tex.	0.01
New Orleans	La.	0.02	El Paso	Tex.	0.02
Augusta	Maine	0.02	Salt Lake City	Utah	0.02
Presque Isle	Maine	0.02	Richmond	Va.	0.01
Baltimore	Md.	0.02	Seattle	Wash.	0.02
Rockville	Md.	0.01	Charleston	W. Va.	0.02
Lawrence	Mass.	0.02	Madison	Wis.	0.01
Winchester	Mass.	0.02	Cheyenne	Wyo.	0.02

[a] Dash indicates no data received.

Strontium–90 In Human Bone

TRI-CITY BONE SAMPLING[1] 1960–1961

J. Rivera
Health and Safety Laboratory
Atomic Energy Commission

Since March of 1961, the Health and Safety Laboratory (HASL) has been collecting samples of human vertebrae from autopsies performed by pathologists in New York City, Chicago, San Francisco, and San Juan, Puerto Rico. These samples were from individuals whose nutrition and metabolism could reasonably be expected to have been normal just prior to death.

Vertebrae were selected as the bones to be analyzed, because they were expected to have higher strontium–90 concentrations than other bones. Samples were obtained from New York City, Chicago, and San Francisco, because estimates of the dietary intake of strontium–90 in these cities has been made every 3 months since March 1960 as a part of the Tri-City Diet Study (*1*). Samples were obtained from San Juan to see what effect a diet with less milk, and presumably less calcium, would have on the strontium–90 content of bone.

Data summarizing the dietary intake of strontium–90 in the 3 cities during 1960 and 1961 are presented in table 1. The estimates tabulated are based on more than 400 analyses of food made by HASL during the last 2 years.

[1] Quarterly Summary Report, *HASL–127*, p. 214 (July 1, 1962).

TABLE 1.—ANNUAL PER CAPITA DIETARY INTAKE OF STRONTIUM-90

Year	New York City		Chicago		San Francisco	
	μμc/yr	μμc/gm Ca	μμc/yr	μμc/gm Ca	μμc/yr	μμc/gm Ca
1960	4300	11.2	3550	9.2	1700	4.4
1961	3700	9.7	2670	7.0	1290	3.4

The estimated per capita annual intake of strontium–90 and calcium by the lowest income group from San Juan, Puerto Rico, based on a single sampling of foods made in June 1961, was 1340 μμc Sr^{90} per year and 170 gm calcium per year (7.9 μμc Sr^{90}/g Ca) (*2*). Although the diet of individuals in this income group was not considered typical of Puerto Rico, it was likely to have been representative of the diet of the individuals from whom bone samples were obtained.

Estimates of the Sr^{90}/Ca ratio of the diet of infants during the first year of life in New York City, Chicago, and San Francisco, based on analyses of samples of foods especially prepared for consumption by infants, indicated that there was no appreciable difference between the ratio found in infant and adult diets at each of the cities (*3*).

From March 1961 to March 1962, over 450 bone samples were collected, of which 262 were considered suitable to be analyzed singly or as part of composite samples. A summary of the average Sr^{90}/Ca ratios found in the samples is presented in table 2 and plotted in figure 1.

Discussion

The general variation of Sr^{90}/Ca ratios in bone with age can best be seen in figure 1. The distribution with age of the points plotted is in agreement with that found by Kulp and Schulert (*4*), Bryant and Loutit (*5*), and other investigators. A peak from the youngest age bracket to about 5 years old can be noted, as well as a somewhat lower peak during the late teenage years. A gradual tapering off of the ratios in adult bones can also be noted. It may be mentioned that the values plotted are not characteristic of the skeleton as a whole, since no correction has been made for the faster turnover of vertebrae as compared to other bones in the adult.

New York City bones had the highest strontium–90 ratios, Chicago had intermediate ratios, and San Francisco had the lowest ratios, although there were many exceptions where pairs of samples of the same age were compared between cities. These results indicated that there was a direct proportionality between dietary Sr^{90}/Ca ratios and bone Sr^{90}/Ca ratios.

TABLE 2.—WEIGHTED AVERAGE STRONTIUM-90 CONTENT OF HUMAN VERTEBRAE

Age at death	New York City			Chicago			San Francisco			San Juan		
	No. of analyses	No. of samples in composite	Sr^{90} (μμc/gm Ca)	No. of analyses	No. of samples in composite	Sr^{90} (μμc/gm Ca)	No. of analyses	No. of samples in composite	Sr^{90} (μμc/gm Ca)	No. of analyses	No. of samples in composite	Sr^{90} (μμc/gm Ca)
0–1	4	8	3.43	1	1	1.40	2	10	0.49			
1–2	3	5	2.67				3	3	0.79			
2–3	2	2	2.34									
3–4	3	5	2.05	1	1	2.26	3	4	1.33			
4–5	4	4	1.74	2	3	2.08	2	2	2.15			
5–6	1	1	1.51							1	1	0.93
6–7	5	5	1.37									
7–8	3	3	1.62				2	2	0.52	1	1	1.38
8–9							1	1	0.78	1	1	0.80
9–10	2	2	1.20				2	4	1.18			
10–12	2	2	1.55	2	2	1.37	2	2	0.62	2	3	0.85
12–14	2	2	0.62	1	2	1.03	1	1	0.67	1	1	0.89
14–16	3	3	1.16	2	2	1.37	1	1	1.68	1	1	1.69
16–18	6	6	1.44	1	1	1.36				2	3	1.41
18–20	11	11	1.03	3	3	0.48				5	7	1.14
20–40	4	16	1.05	1	10	0.57	3	15	0.50	2	10	0.93
40–60	2	10	0.63	2	20	0.44	2	15	0.46	2	10	0.70
>60	1	5	0.69	1	9	0.76	2	15	0.50	1	5	0.96
Total	58	90		17	54		26	75		19	43	

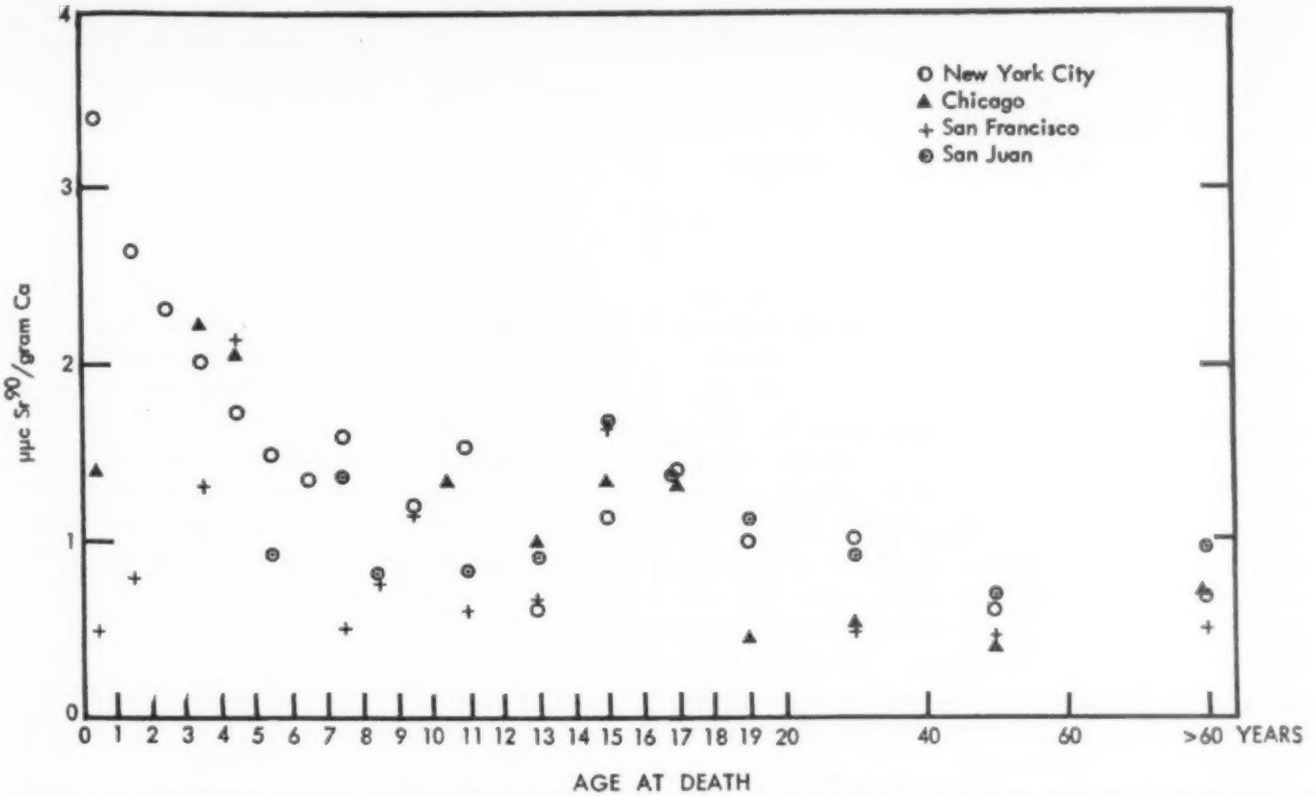

New York City
Chicago
San Francisco
San Juan
μμc Sr90/gram Ca
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 40 60 >60 YEARS
AGE AT DEATH

FIGURE 1.—STRONTIUM-90 IN HUMAN VERTEBRAE COLLECTED FROM MARCH 1961 TO MARCH 1962

The San Juan, P. R., bone Sr^{90}/Ca ratios were comparable to those observed in New York City. Since the intake of Sr^{90} at San Juan was much less than in New York City, the proportionality between bone Sr^{90}/Ca ratios and diet Sr^{90}/Ca ratios is seen to be a true one, and not just a proportionality with total Sr^{90} intake, as might be inferred from the data obtained from the 3 mainland cities alone.

Although dietary intake estimates are available for New York City, Chicago, and San Francisco for 1960, insufficient data exist on bone Sr^{90}/Ca ratios from these cities for 1960 to accurately test the predictive models that have been suggested for strontium-90 levels in man by comparing bone levels from the same area in successive years. However, it should be possible to evaluate the accuracy of these models by this method when data are collected on bone samples obtained from March 1962 to March 1963.

It is hoped that when the current analyses for stable strontium in bone and diet samples are completed, calculations of the specific activity of strontium in bones and that in diet can be used as was done by Bryant and Loutit (*5*) to add to the knowledge of bone metabolism.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1959 and 1960	*May 1960*
1959 and 1960	*July 1960*
1958, 1959 and 1960	*January 1961*
1957, 1958, 1959, 1960	*February 1961*
1957, 1958, 1959, 1960	*April 1961*
1959 and 1960	*May 1961*
1958 and 1959	*June 1961*

REFERENCES

(*1*) USAEC Report No. *HASL–90*: 19–20 (August 18, 1960).
(*2*) USAEC Report No. *HASL–122*: 183 April 1, 1962).
(*3*) USAEC Report No. *HASL–122*: 185 (April 1, 1962).
(*4*) Kulp, J. L. and Schulert, A., "Strontium–90 in Man V," *Science 136*: 619–632 (May 18, 1962).
(*5*) Bryant, F. J. and Loutit, J. F., "Human Bone Metabolism Deduced From Strontium Assays," *U. K. Report No. AERE–R 3718*, HMSO, London (1961).

CANADIAN HUMAN BONE SAMPLING PROGRAM[1]
1960

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

For this program samples of human bone are obtained through the cooperation of hospital pathologists and are analyzed for strontium–90. During 1960 the program was expanded considerably and samples are now received from nearly all of the major cities in Canada. Starting at the beginning of the year sample collection was modified in two ways: (1) by limiting the bone type to vertebrae, in order to provide a more consistent set of data; and (2) by selecting samples as much as possible in line with population distribution. However, the number collected from each region is not sufficient to permit a statistical study of possible regional or age differences.

Results

The results of the analyses are shown in table 3, arranged in groups according to the ages of the subjects from which the samples were taken. In some cases samples from several subjects were pooled in order to obtain enough material for the analyses. Average values of the concentration are taken over the total number of subjects, the results for pooled samples being regarded as sub-averages.

As discussed in the Annual Report for 1959 (*1*), the concentration of strontium–90 in vertebrae does not accurately represent the average concentration in the whole skeleton, which is expected to be lower by a factor of 1.8. In children, however, the concentration in the different parts of the skeleton is expected to be more uniform.

The average values for the different age groups are shown in the histogram in figure 2. In adults, the lower values assumed for the whole skeleton (factor, 1.8) are represented by a dotted line. Since this factor does not apply to children, the line is not extended into the younger age groups.

It is of interest to compare these data with the corresponding values in 1959. In general, it would appear that the average concentration of strontium–90 in human bone has increased by a factor of about 1.5 in children and by a factor of about 2 in adults. This increase is roughly in agreement with the prediction in the 1959 report, which was based on a mathematical analysis of the data at that time. This predicted value is shown in figure 1. It was based on the assumption of a continued, almost linear increase in the concentration in the diet. Actually, as has been demonstrated by milk in this report, the concentration in food decreased somewhat during the year. If allowance was made for this, the calculated level would be reduced slightly, tending to bring it into better agreement with the observed values.

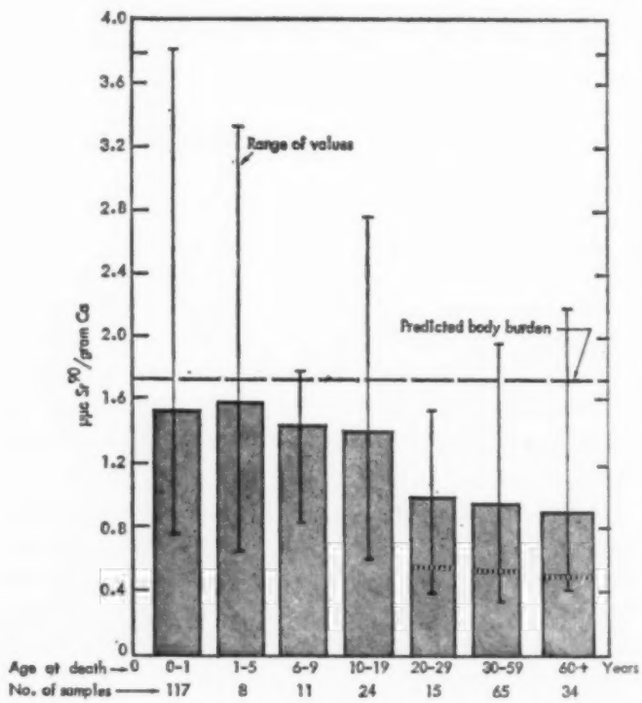


FIGURE 2.—HUMAN BONE DATA, 1960

[1] Bird, P. M., A. H. Booth, and P. G. Mar, *Annual Report for 1960 of the Radioactive Fallout Study Program, CNHW (RP–4)* December 1961.

TABLE 3.—STRONTIUM-90 IN HUMAN BONE SAMPLES

Age group	Location of hospital contributing sample	No. of subjects (pooled)	Strontium-90 (μμc/gm Ca)
0–1 year			
0–12 mo.	Toronto	5	2.32
0–19 hr.	Montrea	12	0.89
0–1 day		6	0.77
0–1 day		13	0.96
1–3 day		12	0.88
5–10 day		6	1.42
0–1 mo.		7	0.82
0–40 day		17	1.16
14–35 day		10	1.22
1–5 mo.		5	2.08
2–6 mo.		7	1.88
2–8 mo.		3	3.71
6–12 mo.		14	3.36
		117	1.52 (Avg)
1–5 years	Edmonton	1	1.31
	Regina	1	1.28
	Toronto	1	1.49
	Montreal	3	0.65
		2	3.31
		8	1.58 (Avg)
6–9 years	Regina	1	1.65
		1	0.93
		1	1.53
	Sault Ste. Marie	1	1.28
	Toronto	1	1.11
	Montreal	1	1.05
		1	1.77
		1	0.83
	Quebec	1	3.07
		1	1.67
	Halifax	1	0.85
		11	1.43 (Avg)
10–19 years	Victoria	1	1.52
		1	1.53
	Vancouver	1	1.71
		1	1.90
		1	0.97
		1	2.04
		1	0.89
	New Westminster	1	1.33
	Saskatoon	1	1.36
		1	0.62
	Winnipeg	1	1.96
	Sault Ste. Marie	1	1.06
		1	0.78
		1	1.27
	Montreal	1	1.36
		1	1.64
		1	1.93
		1	0.91
		1	1.41
		1	0.59
	Quebec	1	1.60
		1	1.35
		1	1.75
	Halifax	1	2.75
		24	1.41 (Avg)
20–29 years	Victoria	1	1.18
	Vancouver	1	0.69
		1	0.39
	New Westminster	1	0.99
	Edmonton	1	0.41
		1	0.76
	Regina	1	1.30
		1	0.62
	Saskatoon	1	1.26
	Kingston	1	1.05
	Ottawa	1	0.97
		1	0.98
	Montreal	1	1.24
	Quebec	1	0.92
	Halifax	1	1.52
		15	0.96 (Avg)
30–59 years	Victoria	1	0.58
		1	0.44
		1	0.76
		1	0.70
	Vancouver	1	1.55
		1	0.37
		1	0.78
		1	1.50
		1	0.77
		3	0.71
		2	0.73
	New Westminster	1	1.14
		1	0.56
	Edmonton	1	0.99
		1	1.97
		1	0.88
		1	0.33
		1	0.62
		1	0.79
		1	0.74
	Calgary	1	0.68
	Regina	1	0.92
		1	0.61
		1	1.21
	Winnipeg	1	1.18
		1	1.27
		1	1.48
	St Boniface	1	0.77
		1	1.19
	Sault Ste. Marie	1	0.93
		1	0.64
		1	0.79
	Toronto	1	0.49
	Kingston	1	0.53
		1	0.51
	Ottawa	1	0.69
		1	0.84
		1	1.37
		1	0.74
		1	0.57
		1	0.72
		1	0.91
		1	1.07
		1	0.85
		1	1.00
		1	0.55
		1	1.17
		1	0.78
	Montreal	1	0.93
		1	0.79
		1	1.52
		1	0.84
		1	1.23
		1	1.48
		1	1.37
		1	1.92
	Quebec	1	0.84
		1	0.80
	Halifax	1	1.69
		1	1.44
		1	1.37
		65	0.92 (Avg)
60 years and over	Victoria	1	1.03
		1	0.72
		1	0.61
		1	0.77
		1	0.66
	Vancouver	1	0.70
		1	0.65
		3	0.83
	New Westminster	1	1.40
	Edmonton	1	0.77
	Calgary	1	0.94
	Regina	1	0.41
		1	0.73
	Winnipeg	1	1.41
		1	1.38
	Kingston	1	0.57
		1	0.53
	Ottawa	1	0.94
		1	1.05
		1	0.93
		1	0.84
		1	0.65
		1	0.97
		1	0.91
		1	1.23
		1	0.78
	Montreal	1	0.61
		1	0.89
		1	2.16
		1	0.65
		1	0.40
	Halifax	1	0.87
		34	0.87 (Avg)

REFERENCE

(1) Bird, P. M., A. H. Booth, and P. G. Mar, *Annual Report for 1959 of the Radioactive Fallout Study Program, CNHW (RP–3)* May 1960.

Previous bone data in *Radiological Health Data:*

Period	*Issue*
1958, 1959, and 1960 (human, USA)	*May 1960*
1959 and 1960 (human, USA)	*July 1960*
1958, 1959, and 1960 (human, USA)	*January 1961*
1957 and 1958 (human, animal, Canada, USA)	*February 1961*
1960 (human, USA)	*March 1961*
1957 through 1960 (human, USA)	*April 1961*
1959 and 1960 (human, USA)	*May 1961*
1958 and 1959 (human, Japan)	*June 1961*
1960 (bovine, USA)	*August 1961*
1956 through 1961 (animal, worldwide)	*March 1962*

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Various summaries of the environmental radioactivity data for 21 AEC installations have appeared in *Radiological Health Data* since November 1960. Summaries follow for Oak Ridge Area, Portsmouth Area Gaseous Diffusion Plant, and Savannah River Plant for third and fourth quarters 1961.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposure given in National Bureau of Standards, *Handbook 69.*[1] The MPC values applicable to the following reports are given in table 1.

To avoid any possible misunderstandings in the use of the term "Maximum Permissible Concentrations," the Federal Radiation Council (FRC) has recommended the term "Radioactivity Concentration Guide" (RCG) for the use of Federal Agencies. Although FRC has not published a table of RCG values, several AEC installations, such as Savannah River Plant, have adopted FRC nomenclature and use the NCRP published values or derive their own RCG values. For a more detailed description of the meaning and use of the RCG, the reader is referred to FRC Report No. 2.[2] Radiation Protection Guides (RPG's) in terms of total intake in $\mu\mu$c/day averaged over a 1-year period are reported in FRC Report No. 2 for radium, iodine–131, and strontium–90. (See footnote b in table 1, below.)

In the following reports, the use of nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justify a less restrictive value. References to table 1 will be made to designate the appropriate MPC's reported by the laboratories.

[1] National Bureau of Standards, *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, Handbook 69,* Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (June 5, 1959) Price 35 cents.

[2] Federal Radiation Council, *Background Material for the Development of Radiation Protection Standards, Report No. 2,* Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 1961) Price 20 cents.

TABLE 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS BELOW

Line	Radionuclide or mixture of unknown nuclides	Environmental MPC's	
		Water ($\mu\mu$c/liter)	Air ($\mu\mu$c/m^3)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present [a]	3,000	—
2	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present [a]	600	—
3	If Ra^{226}, Ra^{228} are not present [a]	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present [a]	—	1.0
6	If α emitters and Pb^{210}, Ro^{227}, Ra^{228}, Pu^{241} are not present [a]	—	10
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present [a]	—	100
8	Cerium–144	10,000	200
9	Cesium–137	20,000	500
10	Cobalt–60	30,000	300
11	Hydrogen-3 (tirtium)	3,000,000 [b](300,000)	200,000
12	Iodine–131	2,000 [b](700)	300 [b](100)
13	Ruthenium–103–106	10,000	200
14	Strontium–90	100 [b](33)	10
15	Thorium–234	20,000	100
16	Uranium-natural	20,000	2

[a] "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to AEC regulations, a group of nuclides may be considered not present if the ratio of each nuclide is equal to or less than 1/10 of its appropriate MPC and if the sum of these ratios for the group in question is equal to or less than 1/4.

[b] Numbers in parentheses are the RCG values used by the Savannah River Plant The RPG's for daily intake of iodine–131 and strontium–90 as recommended by FRC (top of range II) are 100 and 200 $\mu\mu$c/day, respectively.

OAK RIDGE AREA

Third and Fourth Quarters 1961

Union Carbide Nuclear Company
Oak Ridge, Tennessee

This report presents third and fourth quarter 1961 data on the environmental levels of radioactivity for the Oak Ridge Area. As shown in figure 1, K–25 Area, X–10 and Y–12 areas are located within the large AEC-controlled Oak Ridge Area. The Oak Ridge National Laboratory (ORNL) is located within the X–10 area and the Oak Ridge Gaseous Diffusion Plant (ORGDP) is located within the K–25 area.

Radioactive waste materials arising from the operation of atomic energy installations at Oak Ridge are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by ion exchange. Liquid wastes, which contain long-lived fission products, are confined in storage tanks or are released to trenches and pits located in the Conasauga shale formation. Low level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air Monitoring

Atmospheric contamination by long-lived fission products and fallout occurring in the general environment of East Tennessee are monitored by 2 systems of monitoring stations. One system consists of 7 stations which encircle the plant areas (figure 1) and provides data for evaluating the impact of all Oak Ridge Operations on the immediate environment. A second system consists of 8 stations encircling the Oak Ridge Area at distances of from 12 to 120 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur. Sampling is carried out by passing air continuously through a filter paper. Average concentrations are tabulated in table 2.

Atmospheric contamination by uranium was determined during the third quarter by taking

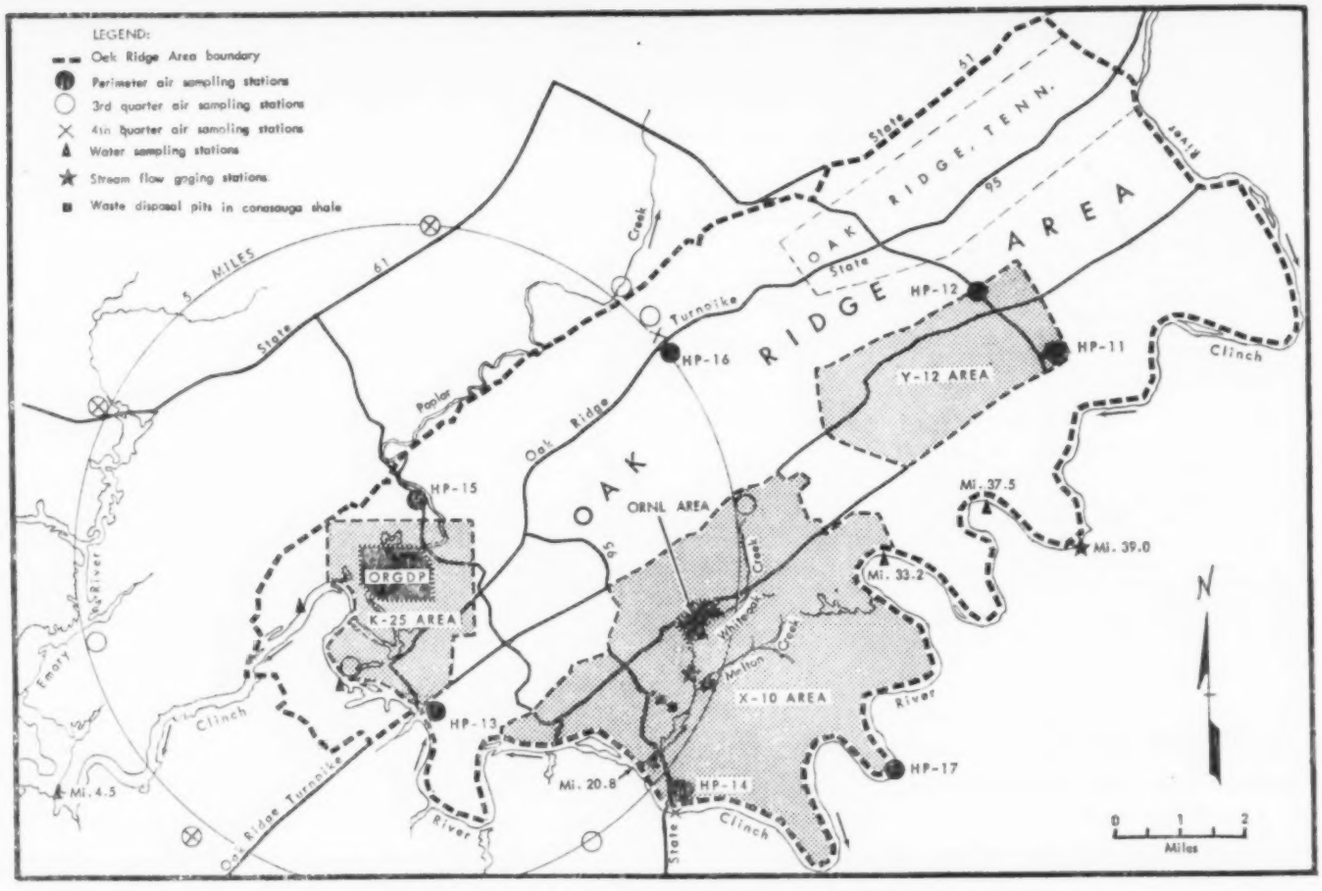


FIGURE 1.—OAK RIDGE AREA ENVIRONMENTAL SAMPLING LOCATIONS

periodic air samples at eight locations on a five-mile radius from the ORGDP (figure 1). In the fourth quarter, the procedure was changed to provide continuous sampling at the five sites indicated in figure 1.

The average beta activity in air during this six-month period was considerably higher than the levels of the first and second quarters of 1961. However, this increase is attributed to weapons test fallout which began arriving in the Oak Ridge area on September 17, 1961. The air contamination collected on the filters was identified by gamma spectrometry as mixed fission products such as might be expected from weapons tests. These activity levels are no greater than the average of those measured in other areas of the United States.

The average air-borne alpha activity as measured five miles from the ORGDP did not increase appreciably over previous quarters; and the third and fourth quarter levels were 2.3 and 12 percent respectively of the maximum permissible concentration for populations in the neighborhood of a controlled area.

TABLE 2.—LONG-LIVED GROSS BETA CONCENTRATIONS IN AIR, OAK RIDGE AREA

[Average concentrations in $\mu\mu c/m^3$]

Station number (see figures 1 and 2)	Third quarter 1961		Fourth quarter 1961	
	Number of samples	Average gross β	Number of samples	Average gross β
Perimeter stations:				
HP-11	14	2.05	13	3.2
HP-12	14	2.18	13	3.7
HP-13	14	1.98	13	3.5
HP-14	14	1.65	13	3.2
HP-15	14	2.09	13	4.0
HP-16	14	1.90	13	3.4
HP-17	14	2.28	13	3.6
All perimeter stations	98	2.09	91	3.5
Remote stations:				
HP-19	14	2.28	13	4.1
HP-20	14	2.66	13	3.8
HP-21	14	2.31	13	4.3
HP-22	14	2.04	13	4.1
HP-23	14	3.10	13	4.4
HP-24	14	3.00	13	4.6
HP-25	14	1.72	13	3.7
HP-26	14	1.79	13	3.4
All remote stations	112	2.36	104	4.1

Water Monitoring

Large volume, low level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee

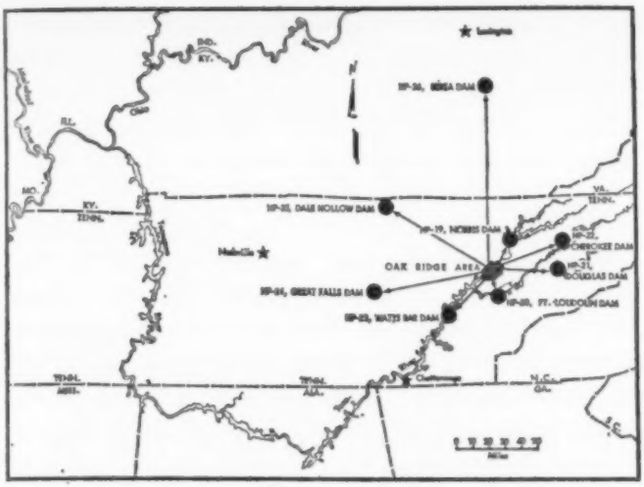


FIGURE 2.—REMOTE AIR MONITORING STATIONS OAK RIDGE AREA

River System by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and the Y–12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with the maximum permissible levels for populations in the neighborhood of a controlled area as recommended by the National Committee on Radiation Protection (NCRP). The concentration of radioactivity

TABLE 3.—CONCENTRATIONS OF ALPHA-EMITTING MATERIALS IN AIR FIVE MILES FROM ORGDP

[Average concentrations in $\mu\mu c/m^3$]

Period (1961)	Type of analysis	Type of sampling	Number of samples	Concentration
Third quarter (8 stations)	Uranium concentration	Random; 10 minute samples	10	0.045
Fourth quarter (5 stations)	Gross alpha*	Continuous	592	0.24

* Interpreted as uranium.

leaving White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tennessee. Stream gauging operations are carried on continuously by the U.S. Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, for uranium, and for the transuranic alpha emitters.

Analyses are made of the effluent for the

TABLE 4.—CONCENTRATIONS OF MAJOR RADIONUCLIDES IN THE CLINCH RIVER

[Average concentrations in $\mu\mu c$/liter]

Radionuclide	Third quarter 1961			Fourth quarter 1961		
	Location on Clinch River [a]			Location on Clinch River [a]		
	Mi. 33.2 (Upstream)	Mi. 20.8[b] (Outfall)	Mi. 4.5 (Downstream)	Mi. 33.2 (Upstream)	Mi. 20.8[b] (Outfall)	Mi. 4.5 (Downstream)
Sr^{90}	1.0	2.3	2.5	0.8	2.8	3.3
Ce^{144}	0.5	0.2	1.1	0.4	1.0	1.8
Cs^{137}	[c]ND	1.7	0.5	0.5	2.5	0.9
$Ru^{103,106}$	4.5	90	59	9.0	370	210
Co^{60}	ND	1.3	0.2	0.6	3.0	3.6
Gross beta	3.0	170	92	2.8	520	240

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.
[b] The concentrations at mi. 20.8 are not measured directly but the values calculated on the basis of levels of waste released and the dilution afforded by the river. These concentrations therefore do not include activity from fallout and therefore are not directly comparable to measured activity at the other points.
[c] ND—indicates none detected.

TABLE 5.—URANIUM CONCENTRATION IN THE CLINCH RIVER, OAK RIDGE AREA

[Average concentrations in $\mu\mu c$/liter]

Sampling location	Third quarter 1961		Fourth quarter 1961	
	Number of samples	Uranium concentration	Number of samples	Uranium concentration
Upstream from ORGDP	14	1.8	13	1.1
Downstream from ORGDP	13	2.7	12	2.3

TABLE 6.—EXTERNAL GAMMA RADIATION LEVELS, OAK RIDGE AREA

[Average dose rates in mr/hr]

Location	Third quarter 1961	Fourth quarter 1961
Solway Gate	0.015	0.021
Y-12 East Portal	0.018	0.019
Newcomb Road	0.017	0.020
Gallaher Gate	0.023	0.023
White Wing Gate	0.021	0.019
Average	0.019	0.020

long-lived radionuclides only, since cooling time and holdup time in the waste effluent system is such that short-lived radionuclides are not present. The averages are tabulated in tables 4 and 5.

Gamma Measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge Area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above ground, and the results are tabulated in table 6 in terms of mr/hr. Although a slight increase was noted over the first and second quarter levels, the time of this increase coincides with the arrival of weapons test fallout.

Conclusion

The air and ground contamination in the immediate and remote environs of Oak Ridge increased during the third and fourth quarters of 1961, but was identified as originating from sources other than local plant operations.

The release of low level radioactive liquid wastes contributes some radioactivity to the Clinch River, but the concentrations remain well below the maximum permissible concentration recommended by the NCRP.

Previous coverage in *Radiological Health Data*

Period	*Issue*
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*July 1961*
First and second quarters 1961	*January 1962*

PORTSMOUTH AREA GASEOUS DIFFUSION PLANT
Third and Fourth Quarters 1961

Goodyear Atomic Corporation
Portsmouth, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium–234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium–234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

Air samples are collected monthly at 17 sites located from 1 to 6 miles from the plant as shown in figure 3. Monthly water samples are collected at 14 locations within 5 miles of the plant.

Average alpha and beta-gamma concentrations in air and water are summarized in table 7. The external gamma levels are measured at the air sampling locations shown in figure 3 and the results included in table 7.

A marked increase of airborne beta-gamma

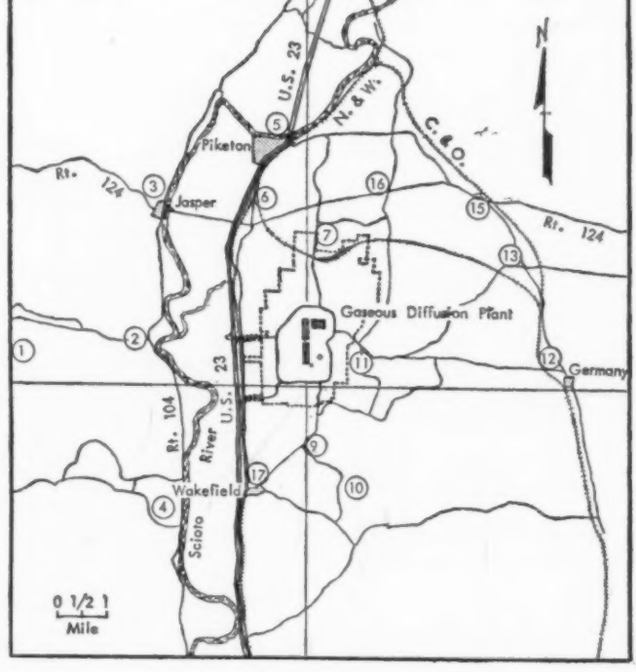


FIGURE 3.—AIR SAMPLING LOCATIONS, PORTSMOUTH GASEOUS DIFFUSION PLANT

TABLE 7.—AVERAGE LEVELS OF RADIOACTIVITY IN THE ENVIRONMENT OF THE PORTSMOUTH PLANT

Basis of measurement	Third quarter 1961		Fourth quarter 1961	
	Number of samples	Concentration	Number of samples	Concentration
Air-alpha concentration	45	0.1 μμc/m³	45	0.1 μμc/m³
Air-beta-gamma concentration	45	0.7 μμc/m³	45	5.2 μμc/m³
Water-alpha concentration	40	27 μμc/liter	38	30 μμc/liter
Water-beta-gamma concentration	40	62 μμc/liter	38	49 μμc/liter
External gamma	45	0.013 mrad/hour	45	0.019 mrad/hour

activity was noted during the fourth quarter 1961. However, this increase was expected because of the resumption of nuclear weapons testing in September 1961. The constant alpha activity levels imply that the beta-gamma increase was not a result of plant operations.

Water alpha and beta-gamma concentrations remain essentially unchanged from previous quarters. The slight increase in external gamma dose rate is evidently a consequence of nuclear weapons testing fallout. Total amount of radiation detected was too small to determine the amount, if any, attributable to plant operations.

Previous coverage in *Radiological Health Data*

Period	*Issue*
1959 and first quarter 1960	*November 1690*
Second and third quarters 1960	*March 1961*
Fourth quarter 1960	*August 1961*
First and second quarters 1961	*February 1962*

SAVANNAH RIVER PLANT
Third and Fourth Quarters 1961

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP) maintains a continuous monitoring program to determine the concentrations of radioactive materials in a 1200 square mile area outside the plant perimeter. Included in this area are parts of Aiken, Barnwell, and Allendale Counties in South Carolina and Richmond, Burke, and Screven Counties in Georgia. This program, initiated in 1951 prior to plant operations, is carried out by the Health Physics Section of E. I. du Pont de Nemours and Company, prime contractor for operation of the plant for the Atomic Energy Commission.

Although plant operations discharge some very low level gaseous and liquid wastes to the environment by controlled releases, dispersal is adequate to insure that the concentration of radioactive materials is well below the Radiation Concentration Guide (RCG) included in table 1. Continuous surveillance of the Savannah River Plant provides information useful both as a measure of the effectiveness of plant controls and as evidence of the strict adherence to the recommended RCG.

In most cases during the autumn of 1961, the low levels of radioactivity released to the environs by the SRP were obscured by fallout from the U.S.S.R. nuclear weapons testing.

Atmospheric Monitoring

Continuous air and rainwater samples are collected at 15 monitoring stations. These stations, which include 5 locations at the plant perimeter and 10 locations approximately 25 miles from the center of the plant, are spaced so that a measurable plant release of radioactivity to the air would be detected regardless of prevailing wind conditions (see figure 4). Four additional air monitoring stations are operated approximately 100 miles from the plant at Savannah and Macon, Georgia, and Columbia and Greenville, South Carolina (see figure 5). At this distance, the effect of SRP operations is minimal, and, therefore, these facilities serve as "reference points" for determining background levels of activity. The complete system of 19 stations permits a comprehensive surveillance of atmospheric radioactivity and differentiation between weapons testing fallout and plant releases. The average concentrations of radio-

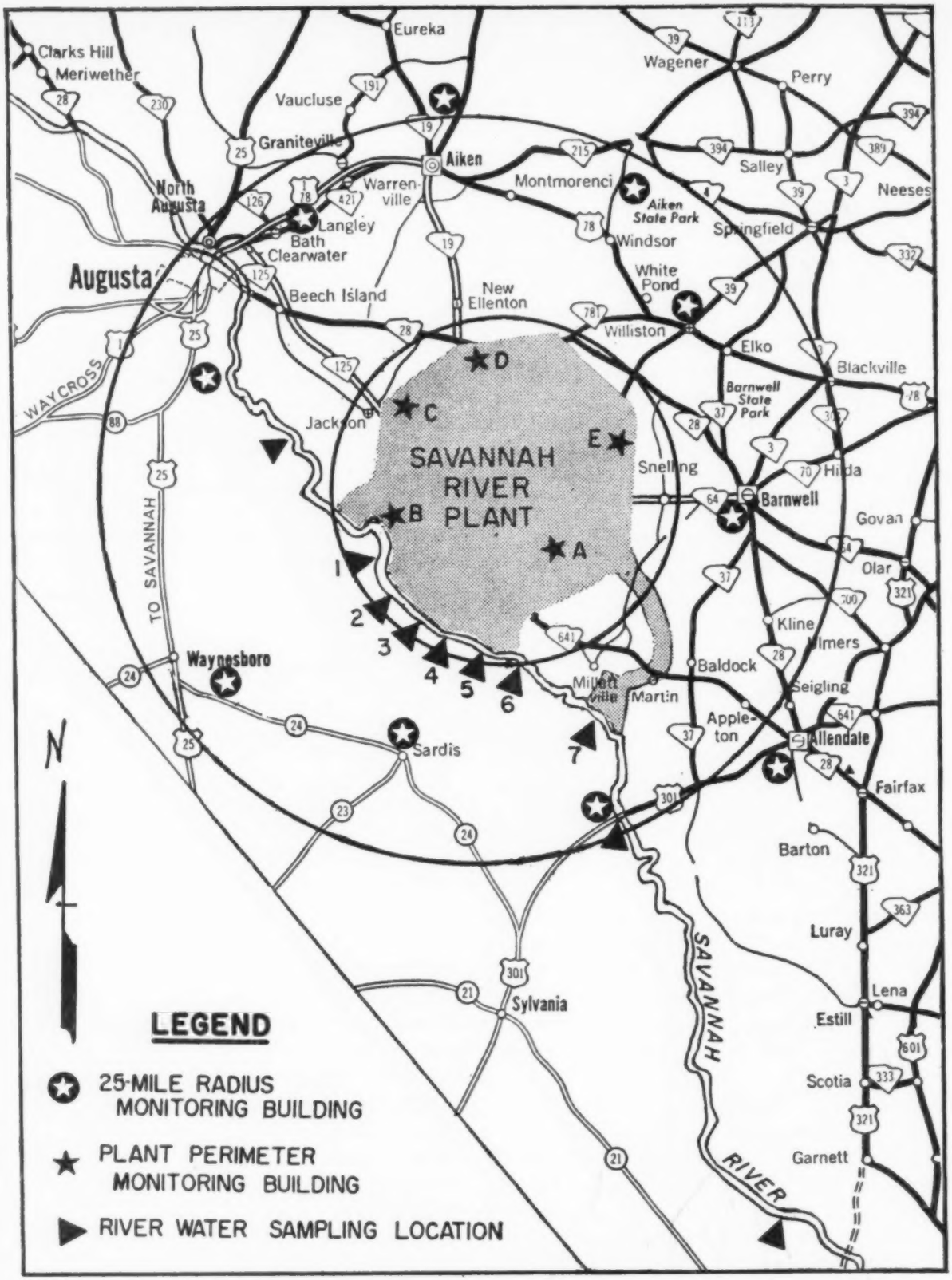


FIGURE 4.—ENVIRONMENTAL SAMPLING LOCATIONS, SAVANNAH RIVER PLANT

FIGURE 5.—DISTANT AIR MONITORING STATIONS, SAVANNAH RIVER PLANT

activity in air and rainwater are given in tables 8 and 9. The increase noted in radioactivity during this period is explained by the arrival of fallout from weapons testing which began in September 1961.

Milk

Milk samples were collected weekly from dairies and farms in Aiken, North Augusta, Snelling, Talatha, and Langley, South Carolina, to be analyzed for tritium and radioiodine content. Quarterly samples of milk were taken from the above locations; Williston, South Carolina; and Waynesboro and Sylvania, Georgia, for analysis of strontium–90 content. Average concentrations of tritium, iodine–131, and strontium–90 are given in table 10.

The concentration of strontium–90 in milk during this period was not significantly higher than in previous quarters and showed no effect of the 1961 nuclear tests. However, radioiodine contamination from fallout was evident, and the exposure to young children from consumption of iodine–131 contaminated milk in the vicinity of the plant for the calendar year 1961 is of particular interest. The cumulative thyroid dose due to consumption of contaminated dairy milk (resulting both from plant-released radioiodine in early June and from weapons test fallout) was below the 500 mrem annual limit recommended by the Federal Radiation Council, as shown below. The calculations were based on average concentrations in dairy milk, a child's thyroid weighing 2 grams, and the consumption of one liter of milk daily. An adult consuming one liter of milk daily would have received only 10 percent of a child's thyroid exposure.

1961	Average population dose to a child (mrem)
June	63
September	102
October	93
November	27
December	6
Total	291

The June dose was caused by plant release. All the other doses were due to weapons test fallout. Concentrations of radioiodine in milk

TABLE 8.—RADIOACTIVITY IN AIR

[Average concentrations in $\mu\mu c/m^3$]

Period	Source of samples	Alpha	Nonvolatile beta	Iodine–131
Third quarter 1961	Plant perimeter	0.0005	1.8	0.1
	25-mile radius	0.0005	2.1	0.1
	100-mile radius	0.0008	2.8	NS*
Fourth quarter 1961	Plant perimeter	0.0007	5.5	0.2
	25-mile radius	0.0008	5.0	0.2
	100-mile radius	0.0009	4.7	NS

* NS indicates no sample.

TABLE 9.—RADIOACTIVITY IN RAINWATER

[Average concentrations in $\mu\mu c$/liter]

Period	Source of samples	Alpha	Nonvolatile beta	Iodine–131
Third quarter 1961	Plant perimeter	0.4	99	18
	25-mile radius	0.3	72	14
Fourth quarter 1961	Plant perimeter	0.4	1740	61
	25-mile radius	0.5	1100	52

TABLE 10.—RADIOACTIVITY IN MILK

[Average concentrations in μμc/liter]

Type of test	Third quarter 1961	Fourth quarter 1961
Tritium (H^3)	7000	4600
Iodine-131	59	98
Strontium-90		
Single cow samples	27	27
Local dairies	11	12
Major distributors	13	12

during 7 months of 1961 (January through May and July through August) were below the limit of detection (6 μμc/liter).

Vegetation

Bermuda grass, because of its importance as a pasture grass for dairy herds and its year-round availability, was selected for analysis of radioactive contamination.

Average concentrations of alpha emitters, nonvolatile beta emitters, and radioiodine found on vegetation collected at the air monitoring locations shown in figure 4 are summarized in table 11.

The increase of radioiodine concentration over previous quarters was coincident with the arrival of weapons test fallout. As indicated by the relatively small difference of concentrations between plant perimeter and distant locations, the radioiodine fallout showed no correlation with plant releases.

Algae and Fish in Savannah River

Determination of radioactivity concentrations in algae is important because algae are concentrators of specific radionuclides and also have an important relationship in the food chain of aquatic organisms. Indigenous algae samples were collected weekly upstream from, adjacent to, and downstream from the plant. The average nonvolatile beta concentrations are given in table 12. Some correlation of plant effluent entry into the river is indicated by the lower upstream values.

TABLE 12.—NONVOLATILE BETA IN SAVANNAH RIVER ALGAE

[Average concentrations in μμc/gm]

Period	Location	Nonvolatile beta
Third quarter 1961	Adjacent to plant	67
	Upstream	24
	Downstream	34
Fourth quarter 1961	Adjacent to plant	242
	Upstream	51
	Downstream	81

Fish taken from the river showed no evidence of plant-contributed radioactivity.

Water Monitoring

Communities in the vicinity of SRP obtain sanitary water from deep wells or surface streams. Public water samples are collected monthly from 14 surrounding towns. Savannah River water is sampled continuously at 7 locations. Six of the locations are shown in figure 1; the seventh is 60 miles downstream from the plant.

Quarterly average concentrations of alpha and beta activity in public and Savannah River water are presented in table 13. The values shown indicate that plant operations contribute small amounts of radioactivity to the Savannah River, but the resulting concentrations are far below RCG values.

External Gamma Radiation Levels

Environmental gamma radiation dose rates are measured continuously at the 15 air monitoring stations shown in figure 4. The average dose rates at the plant perimeter were 0.34 mr/24 hours for both the third and fourth quarters. At the 25-mile radius locations, the rates were 0.34 and 0.38 mr/24 hours for the third and fourth quarters, respectively. For comparison, the North American average of environmental gamma radiation was 0.41 mr/24 hours during September 1961 (see *Radiological Health Data*, December 1961, p. 533).

TABLE 11.—RADIOACTIVITY IN VEGETATION (BERMUDA GRASS)

[Average concentrations in μμc/gm]

Period	Source of samples	Alpha	Nonvolatile beta	Iodine-131
Third quarter 1961	Plant perimeter	<0.12	18	3.0
	25-mile radius	<0.12	28	3.0
Fourth quarter 1961	Plant perimeter	0.15	127	3.7
	25-mile radius	0.17	118	3.5

TABLE 13.—RADIOACTIVITY IN WATER

[Average concentrations in μμc/liter]

Period	Source of samples	Alpha	Nonvolatile beta	H^3	Sr^{90}
Third quarter 1961	Public water supplies	1.0	7	—	—
	Savannah River water				
	3 miles upstream	0.2	8	6,000	0.4
	10 miles downstream	0.3	17	11,000	0.6
Fourth quarter 1961	Public water supplies	1.1	9	—	—
	Savannah River water				
	3 miles upstream	0.3	9	4,000	0.4
	10 miles downstream	0.3	40	17,000	0.9

Conclusion

Radioactivity in the environs of the SRP during the third and fourth quarters of 1961 was primarily from weapons test fallout.

Previous coverage in Radiological Health Data:

Period covered	*Issue*
1959 and first quarter 1960	*December 1960*
Second and third quarters 1960	*May 1961*
Fourth quarter 1960	*August 1961*
First and second quarters 1961	*February 1962*

Strontium–90 in Animal Feeds
1961

Pharmacology Division
Food and Drug Administration

A part of the continuing surveillance of radioactivity in foods by the Food and Drug Administration is concerned with the levels of strontium–90 in animal feeds. The samples are analyzed in a manner similar to food items, as indicated in Section II of this issue. Data on strontium–90 in animal feeds appear in table 1.

The leafy types of animal feeds continue to show increased concentrations of strontium–90, as indicated by alfalfa. The influence of geography on strontium–90 levels in animal feeds is not clearly evident from the data in the table.

TABLE 1.—STRONTIUM–90 CONTENT OF ANIMAL FEEDS

Product	Origin			Harvest date	Strontium-90 (μμc/kg)
	Harvest region	State	County		
Grasses and hays:					
Alfalfa	4	Minn.	Wright	June 1961	320
	7	Ohio	Wood	July 15, 1961	239
	10	W. Va.	Jefferson	July 1961	365
	11	Pa.	York	July 1961	779
Clover	11	N. Y.	Erie	June 1961	506
Cowpea hay	9	S. C.	Orangeburg	Nov. 1961	52*
Hay	11	Pa.	Dauphin	Nov. 1961	297*
Peanut hay	9	N. C.	Bladen	Oct. 1961	520*
			Halifax	Nov. 1961	845*
Soybean hay	9	Ga.	Peach	Nov. 1961	25*
		S. C.	Orangeburg	Nov. 1961	57*
Fodders:					
Corn ensilage, wet basis	4	Minn.	Hennepin	Sept. 1961	32
	5	Mich.	Macomb	Sept. 15, 1961	18
				Oct. 12, 1961	9*
	10	N. J.	Sussex	Oct. 10, 1961	64*
Corn silage	9	Ga.	Hart	Aug. 1961	513
				Oct. 1961	63*
	10	Md.	Hartford	Oct. 1961	23*
	11	Pa.	Bucks	Sept. 1961	34
				Oct. 1961	18*
Cotton seed hulls	9	S. C.	10 counties	Sept. 1961	30
Cotton seed meal	3	Ariz.	Pinal	1961	2.9
	8, 9	Ala., Ga.	14 counties	1961	72
	9	Ga.	Jefferson	Nov. 1961	95*
		S. C.	10 counties	Sept. 1961	85
Dried beet pulp	4	Minn.	Renville	Oct. 1961	104*
Dried sugar beet pulp	1	Calif.	Solano, Yolo	Oct. 15, 1961	26*
	5	Mich.	Saginaw	Nov. 1, 1961	112*
	7	Ohio	Wood	Oct. 16, 1961	27*
Sorghum forage	9	Ga.	Hart	Aug. 1961	513

* Indicates harvested after September 15, 1961.

Reported Nuclear Detonations

August 1962

Summary information on nuclear detonations during the month preceding publication is regularly reported in this section of *RHD*. Attention is directed to the following omission from the April 1962 issue: On March 1, 1962, the United Kingdom and the United States jointly conducted a low yield underground test detonation at the Nevada Test Site.

The table below summarizes the available information on nuclear detonations conducted during August 1962. It will be observed that the numbering sequence for the U.S.S.R. detonations continues from their last definitely known test, which was reported in the March 1962 issue; however, the Atomic Energy Commission announced on August 6, 1962, that there were indications that the Soviet Union had resumed testing in the low yield range a few days prior to the test reported for August 5.

Test Number	Location	Date	Yield Range*	Type of Test
REPORTED U.S.S.R. DETONATIONS				
33	Novaya Zemlya	August 5, 1962	30 Megatons	Atmospheric
34	Central Siberia	August 7, 1962	Low yield	Atmospheric
35	Novaya Zemlya	August 10, 1962	Intermediate	Atmospheric
36	Novaya Zemlya	August 20, 1962	Low megaton	Atmospheric
37	Novaya Zemlya	August 22, 1962	Low megaton	Atmospheric
38	Novaya Zemlya	August 25, 1962	Low megaton	Atmospheric
39	Semipalatinsk	August 25, 1962	Low yield	Atmospheric
40	Novaya Zemlya	August 27, 1962	Low megaton	Atmospheric
REPORTED U. S. DETONATIONS				
77	Nevada Test Site	August 24, 1962	Low yield	Underground
78	Nevada Test Site	August 24, 1962	Low yield	Underground

* Low yield range has been announced as less than 20 kilotons yield; intermediate yield is in the range of 20 kilotons up to 1 megaton; and low megaton yield is in the range from 1 to several megatons.

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UNITS AND EQUIVALENTS

For the convenience of the *Radiological Health Data* (*RHD*) reader, a selected list of units and equivalents is presented below.

Symbol	Name	Equivalent
cpm	count per minute	
dpm	disintegration per minute	
$\mu\mu$c	micromicrocurie	1 $\mu\mu$c = 2.22 dpm
nc	nanocurie	1 pc = 1000 pc = 1 mμc
pc	picocurie	1 pc = 1 $\mu\mu$c
mc/km^2	millicurie per square kilometer	1 mc/km^2 = 1000 $\mu\mu$c/m^2 = 2.59 mc/mi^2
mi^2	square mile	
m^2	square meter	
m^3	cubic meter	1 m^3 = 1000 liters
gm	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
ml	milliliter	
mm	millimeter	precipitation: mm = $\frac{\mu\mu c/m^3}{\mu\mu c/liter} = \frac{liter}{m^2}$
mr/hr	milliroentgen per hour	
mrad	millirad	
Mev	million electron volts	

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